SERVICE AND INSTALLATION MANUAL

P.N. #740855

The original version of this manual (Aug.21,1997) has been drafted in the English language by: Communications & Power Industries communications & medical products division.

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CHAPTER 1

PRE-INSTALLATION

1.0 INTRODUCTION

1.1 Purpose

This manual applies to the Indico 100 family of generators and provides instructions for the installation and maintenance of all models of that generator.

This Chapter contains the following sections.

SECTION	TITLE
1A	Introduction
1B	Safety
1C	Preparing for installation
1D	Compatibility listing
1E	Generator layout and Major Components

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CHAPTER 1 SECTION 1A

INTRODUCTION

CONTENTS:

1A.1.0 INTRODUCTION

1A.1.1 Purpose

This manual describes the Millenia and Indico 100 family of 350, 650, 850, and 1050 X-ray generators. The manual provides instructions for the installation and service of these generators.

1A.2.0 GENERATOR DESCRIPTION

Depending on configuration and options, the generator provides the power and interfacing to operate X-ray tubes, buckys, rad tables, GI (gastro-intestinal) tables, remote R&F tables, tomographic devices, and digital imaging systems. The generator consists of power supply and control systems housed in the upper and lower cabinets, a control console, and an optional remote fluoro control along with the necessary interconnecting cable(s).

Major items provided are:

- X-ray generator housed in upper and lower cabinets
- Control console
- Optional remote fluoro control
- Interconnecting cable(s)
- Operator's manual
- Service and installation manual.

1A.3.0 PHYSICAL SPECIFICATIONS

Figure 1A-1 shows the outline of the Millenia series X-ray generator, control console, and remote fluoro control. Figure 1A-2 shows the Indico 100 series X-ray generator outline.

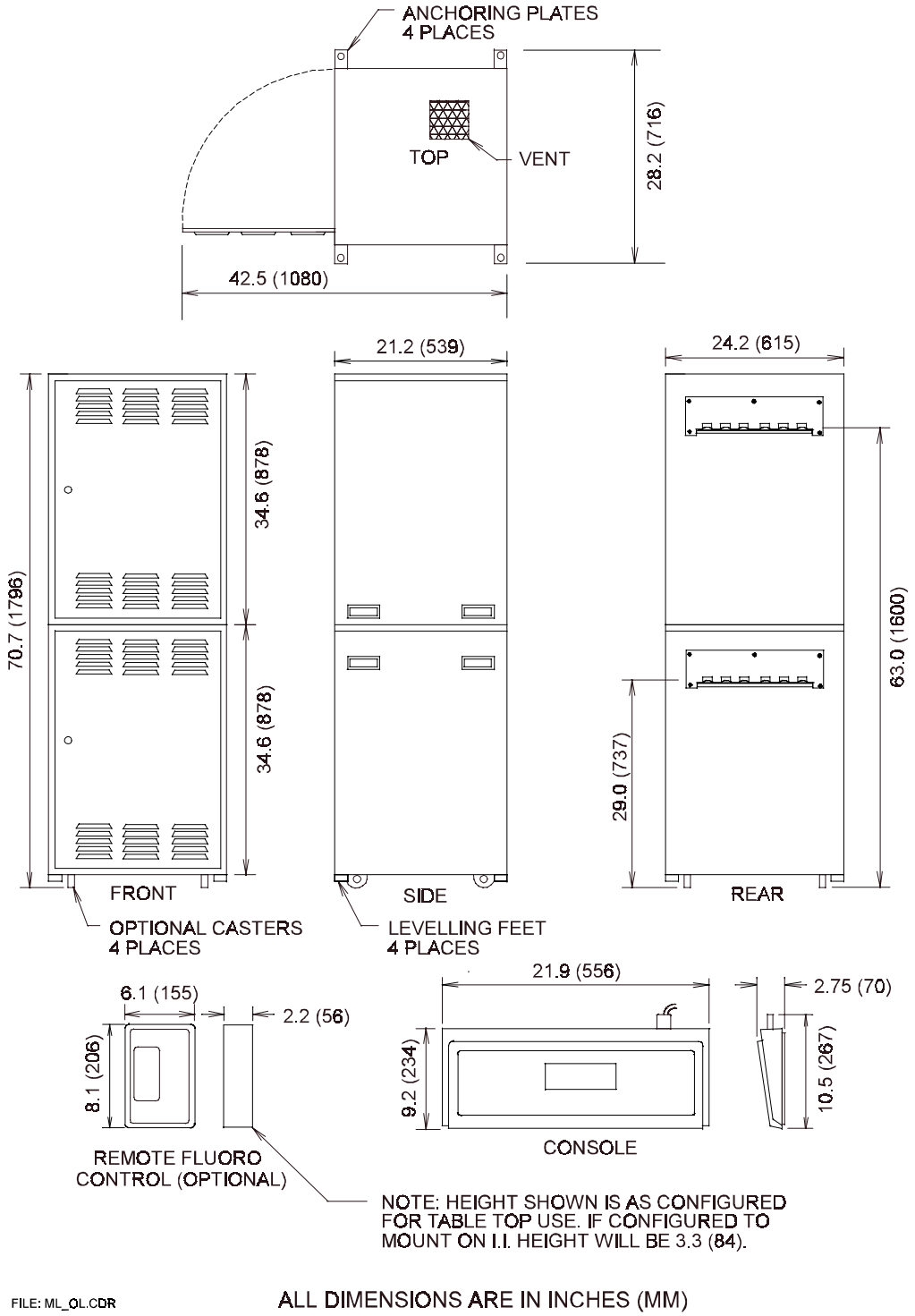

Figure 1A-1: Generator outline drawing (Millenia)

1A.3.0 PHYSICAL SPECIFICATIONS (CONT)

Figure 1A-2 shows the outline of the Indico 100 series X-ray generator.

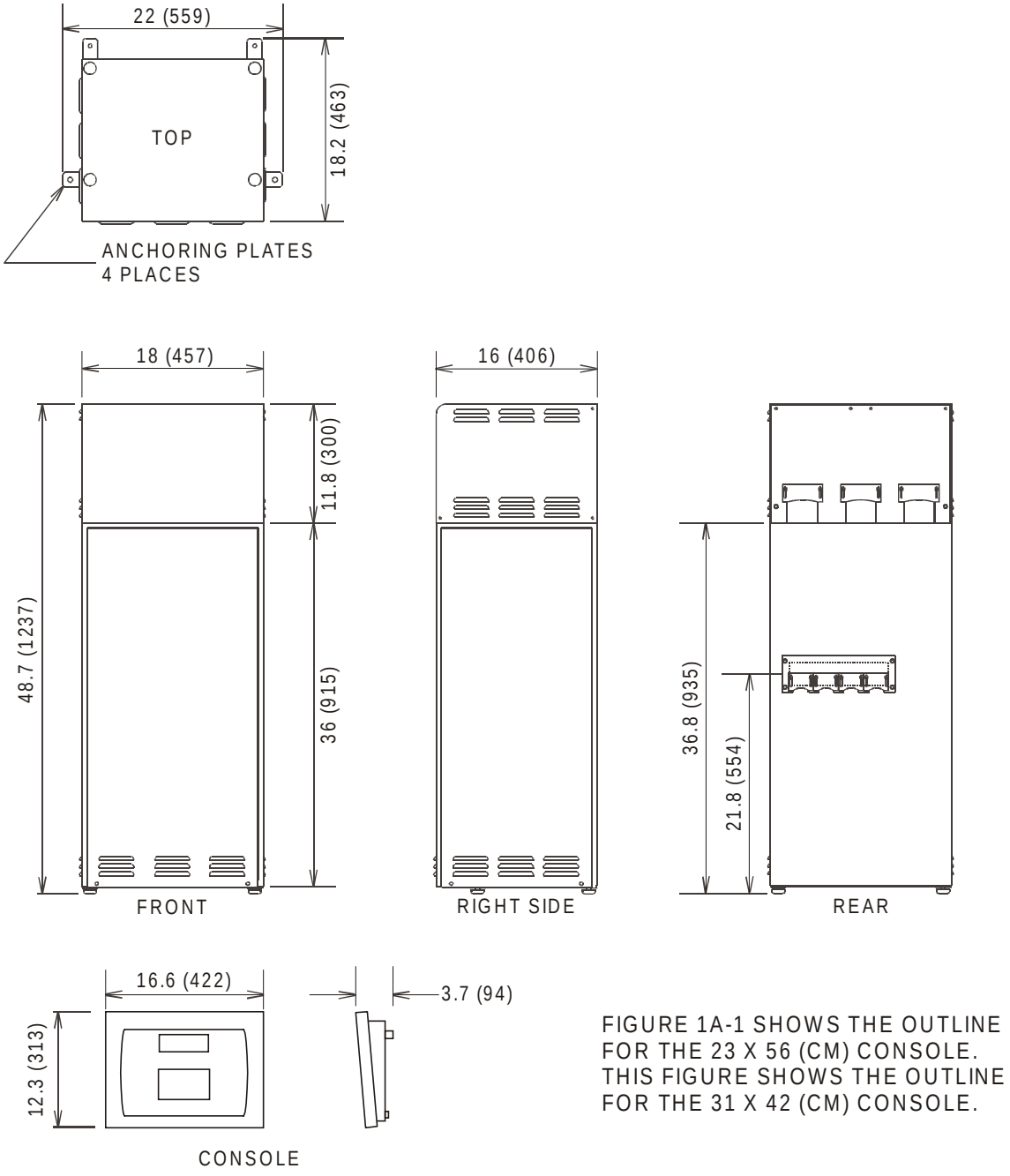

Figure 1A-2: Generator outline drawing (Indico 100)

1A.4.0 APPLICATIONS

RAD SYSTEMS:

- Bucky table, table top and off-table radiography
- Vertical bucky/cassette radiography
- Conventional tomography

R&F SYSTEMS

- Fluoroscopic and spot film applications
- Tomography with conventional and/or remote R&F tables
- Optional digital compatible.

1A.5.0 FEATURES

- High frequency generator.
- One or two tube operation, Rad or Rad / Fluoro.
- Single or dual filament supplies.
- Low speed or dual speed X-ray tube stator supply.
- Optimal matching of X-ray tubes by PROMs.
- Repetitive self checks of generator functions, provides display of system faults and operating errors.
- Optional AEC, up to four inputs.
- Optional ABS with kVp or kVp/mA fluoro stabilizer.
- Optional remote fluoro control box for table top use or SFD mounting.
- X-ray Tube protection. The generator allows setting the following limits:
  a) Maximum mA, adjustable for each focal spot.
  b) Maximum kVp, adjustable for each X-ray tube.
  c) Maximum kW, adjustable for each focal spot.
  d) Maximum filament current limit, adjustable for large and small focal spots.
  e) Anode heat warning and anode heat alarm levels.
- Calibration features :
  a) Microprocessor design allows all calibration and programming to be performed via the Console.
  b) mA calibration is automated.
- Messages and diagnostic information: For users and service personnel, the generator console displays various messages indicating status or equipment problems. The user is prompted in case of errors.
- Error log stores last 200 errors and associated generator settings.
- Service and diagnostic information available via a lap-top computer (optional).
- KVp range: Radiography 40 to 150 kVp.
  Fluoroscopy 40 to 125 kVp.
- mA range: Radiography 10 to 320 mA (30 kW), 10 to 400 mA (37.5 kW), 10 to 630 mA (50 kW), 10 TO 800 mA (65 kW) and 10 to 1000 mA (80 kW).
  Fluoroscopy 0.5 to 6.0 mA.
- mAs range: tube dependent, max 1000 mAs.
- Time range: Radiography 2.0 to 6300 ms.
  Fluoroscopy 0 to 5 or 0 to 10 minutes.

Refer to product description (end of section 1D) for compatibility and features of this specific generator.

1A.6.0 ROTOR CONTROL

The generator will be equipped with a low speed starter, or optional dual speed starter.

DUAL SPEED STARTER

Number of tubes permissible:	Maximum of 32 tube types. Tube type is switch selectable
Current monitoring	Both stator circuits
Dual speed starter output frequency	50 or 60 Hz (low speed) 150 or 180 Hz (high speed). (Independent of line frequency)
Braking	Dynamic braking when in high speed rotation
Rotor boost time	Determined by tube selection plus incremental boost time changes from 100 to 700 msec.
Duty cycle	Not to exceed 2 high speed starts per minute.

LOW SPEED STARTER

Current monitoring	Both stator circuits
Duty cycle	Not to exceed 5 consecutive boosts, followed by a minimum 10 second wait period.

1A.7.0 AUXILIARY POWER OUTPUTS

The generator supplies the following power outputs for X-ray room equipment:

- 24 VDC, 4 Amp.
- 120 VAC, 2.5 Amp.
- 240 VAC, 1.5 Amp.

2.5 AMPS IS AVAILABLE AT 120 VAC OR 1.5 AMPS IS AVAILABLE AT 240 VAC, BUT BOTH ARE NOT AVAILABLE SIMULTANEOUSLY.

The above voltage sources are not compatible with:

- Collimator lamps (24 VDC 150 watts). These lamps exceed the 4 Amp rating of the 24 VDC supply.
- Fluorescent lamps. These have high starting currents and generate transients when the tube strikes.
- Some inductive loads may cause difficulties (some motors and solenoids).

1A.8.0 SYSTEM DOCUMENTATION

The Millenia and Indico 100 series of X-ray generators includes the following documentation:

- Operator's manual.
- Service and installation manual.
- Insert and application notes as required.

1A.9.0 REGULATORIES AND DESIGN STANDARDS

1A.9.1 Environmental Specifications

OPERATING

Ambient temperature range	10 to 40 °C
Relative humidity	30 to 75%
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg)

TRANSPORT AND STORAGE

Ambient temperature range	-20 to 70 °C
Relative humidity	10 to 95%, including condensation
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg)

1A.9.2 Applicable Standards

The Millenia / Indico 100 family of generators complies with the following regulatory requirements and design standards:

- FDA Center for Devices & Radiological Health (CDRH) - 21 CFR title 21 subchapter J (USA).
- Radiation Emitting Devices Act - C34 (Canada).
- Medical Device Regulations (Canada).
- EC Directive 93/42/EEC concerning Medical Devices (European Community).
- IEC 601.1, IEC 601.2.7:1998, CSA 601.1, UL2601.1
  -Type of protection against electric shock: Class I equipment.
  -Degree of protection against electric shock: Not classified.
  -Degree of protection against harmful ingress of water: Ordinary equipment.
  -Mode of operation: Continuous operation with intermittent loading (standby - exposure).
  -Equipment not suitable for use in presence of a FLAMMABLE ANESTHETIC MIXTURE WITH AIR OR WITH OXYGEN OR NITROUS OXIDE.

- IEC 601.1.2

  Immunity:

IEC1000-4-2	Electrostatic discharge
IEC1000-4-3	Radiated RF field
IEC1000-4-4	Electrical fast transient
IEC1000-4-5	Surge
IEC1000-4-6	Conducted RF immunity
IEC1000-4-8	Magnetic field immunity
IEC1000-4-11	Voltage dips, interrupts and variations

  Emission:
  EN55011 (CISPR Publications II Emission Standards, Group 1 Class A).

1A.9.3 Electromagnetic Compatibility (EMC)

In accordance with the intended use, this X-ray generator complies with the European Council Directive concerning Medical Devices. The CE marking affixed to this product signifies this. One of the harmonized standards of this Directive defines the permitted levels of electromagnetic emission from this equipment and its required immunity from the electromagnetic emissions of other devices.

It is not possible, however, to exclude with absolute certainty the possibility that other high frequency electronic equipment, which is fully compliant to the EMC regulations, will not adversely affect the operation of this generator. If the other equipment has a comparatively high level of transmission power and is in close proximity to the generator, these EMC concerns (the risk of interference) may be more pronounced. It is therefore recommended that the operation of equipment of this type such as mobile telephones, cordless microphones and other similar mobile radio equipment be restricted from the vicinity of this X-ray generator.

1A.10.0 TECHNIQUE FACTORS DEFINITIONS

- **KV**: KV peak after any initial kV overshoot.
- **TIME**: Time in milliseconds, (ms) that the high voltage (anode to cathode) is greater or equal to 75% of the desired **kV**.
- **mA**: Average Tube Beam Current (in mA) during the exposure **TIME.**
- **mAs**: milliampere-seconds (**mA** x **TIME**).

Address any questions regarding X-ray generator operation to:

Mail: Customer Support Department
Communications and Power Industries Canada Inc.
45 River Drive
Georgetown, Ontario, Canada L7G 2J4

Telephone: (905) 877-0161

Fax: (905) 877-8320
Attention: Customer Support Department

E-mail: marketing@cmp.cpii.com
Attention: Customer Support Department

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CHAPTER 1 SECTION 1B

SAFETY

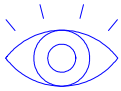
CONTENTS:

1B.1.0 INTRODUCTION

This section contains important safety warnings and safety information required for installing and servicing the generator.

1B.2.0 SAFETY AND WARNING SYMBOLS

The following advisory symbols are used on the safety warning labels, and/or on circuit boards, and/or on the operator console and the optional remote fluoro control.

	High voltage symbol used to indicate the presence of high voltage.
	Warning symbol used to indicate a potential hazard to operators, service personnel or to the equipment. It indicates a requirement to refer to the accompanying documentation for details.
	Radiation exposure symbol used on operator console. Lights to indicate that an exposure is in progress. This is accompanied by an audible tone from the console.
	Fluoro radiation exposure symbol used on operator console and on optional remote fluoro control unit. Lights to indicate that a fluoro exposure is in progress. This is accompanied by an audible tone from the console.
WARNING *THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.*	Radiation warning label on console, used in certain jurisdictions. Never allow unqualified personnel to operate the X-ray generator.

1B.3.0 SAFETY NOTICES AND WARNINGS

<u>WARNING:</u> ***PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO X-RAY GENERATORS ARE THE RESPONSIBILITY OF USERS OF SUCH GENERATORS. CPI CANADA INC. PROVIDES INFORMATION ON ITS PRODUCTS AND ASSOCIATED HAZARDS, BUT ASSUMES NO RESPONSIBILITIES FOR AFTER-SALE OPERATING AND SAFETY PRACTICES.***

THE MANUFACTURER ACCEPTS NO RESPONSIBILITY FOR ANY GENERATOR NOT MAINTAINED OR SERVICED ACCORDING TO THIS SERVICE AND INSTALLATION MANUAL, OR FOR ANY GENERATOR THAT HAS BEEN MODIFIED IN ANY WAY.

THE MANUFACTURER ALSO ASSUMES NO RESPONSIBILITY FOR X-RAY RADIATION OVEREXPOSURE OF PATIENTS OR PERSONNEL RESULTING FROM POOR OPERATING TECHNIQUES OR PROCEDURES.

SAFETY NOTICES AND WARNINGS (cont)

WARNING: ***THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.***

X-ray radiation exposure may be damaging to health, with some effects being cumulative and extending over periods of many months or even years**. Operators and service personnel should avoid any exposure to the primary beam** and take protective measures to safeguard against scatter radiation. Scatter radiation is caused by any object in the path of the primary beam and may be of equal or less intensity than the primary beam that exposes the film.

No practical design can incorporate complete protection for operators or service personnel who do not take adequate safety precautions. **Only authorized and properly trained service and operating personnel should be allowed to work with this X-ray generator equipment**. The appropriate personnel must be made aware of the inherent dangers associated with the servicing of high voltage equipment and the danger of excessive exposure to X-ray radiation during system operation.

Do not connect unapproved equipment to the rear of the console. For the 23 X 56 (cm) console, J5 is used for the interconnect cable to the generator main cabinet, J4 is not used, J2 is a serial port for use by an external computer, and J1 is for connection of an optional printer. For the 31 X 42 (cm) console, J5 is used for the interconnect cable to the generator main cabinet, J2 is a serial port for use by an external computer, and J13 is for connection of an external hand switch and / or foot switch. **INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE**.

CAUTION: ***DO NOT EXCEED THE TUBE MAXIMUM OPERATING LIMITS. INTENDED LIFE AND RELIABILITY WILL NOT BE OBTAINED UNLESS GENERATORS ARE OPERATED WITHIN PUBLISHED SPECIFICATIONS.***

WARNING: ***HAZARDOUS VOLTAGES EXIST INSIDE THE GENERATOR WHENEVER THE MAIN POWER DISCONNECT IS SWITCHED ON. THOSE AREAS INCLUDE THE MAIN FUSEHOLDER AND ASSOCIATED CIRCUITS IN THE HV POWER SUPPLY, PORTIONS OF THE GENERATOR INTERFACE BOARD ON THE UPPER DOOR OF THE GENERATOR, AND THE TERMINALS ON THE LINE ADJUSTING TRANSFORMER IN THE LOWER GENERATOR CABINET IF FITTED***

THE CONSOLE ON/OFF SWITCH DOES NOT DISCONNECT THE MAIN POWER FROM THE ABOVE AREAS INSIDE THE GENERATOR.

THE BUS CAPACITORS, LOCATED ON THE BASE OF THE POWER SUPPLY PRESENT A SAFETY HAZARD FOR AT LEAST 5 MINUTES AFTER THE POWER HAS BEEN REMOVED FROM THE UNIT. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE SERVICING THE GENERATOR.

1B.4.0 SAFETY WARNING LABELS - INTRODUCTION

The safety warning label subsections define the safety labels used inside and outside the generator cabinets. Depending on configuration, your X-ray generator may contain some or all of the labels shown.

NOTE: ***THESE LABELS AND WARNINGS ARE LOCATED TO ALERT SERVICE PERSONNEL THAT SERIOUS INJURY WILL RESULT IF THE HAZARD IDENTIFIED IS IGNORED.***

NOTE: ***DUE TO THE DIVERSITY OF GENERATOR MODELS, THE EQUIPMENT MAY NOT BE EXACTLY AS SHOWN.***

WARNING: ***SWITCH OFF THE MAIN POWER DISCONNECT AND ALLOW SUFFICIENT TIME FOR ALL CAPACITORS TO DISCHARGE BEFORE REMOVING ANY COVERS OR OPENING ANY SERVICE DOOR.***

WARNING: ***IF ANY BARRIERS OR COVERS MUST BE REMOVED FOR SERVICE, TAKE ALL REQUIRED PRECAUTIONS WITH RESPECT TO THE HAZARD(S) AND IMMEDIATELY REPLACE THE BARRIERS/COVERS WHEN THE NEED FOR REMOVAL IS COMPLETED.***

REPLACE ALL FUSES IN THIS GENERATOR WITH THE SAME TYPE AND RATING.

This information is provided to help you establish safe operating conditions for both you and your CPI X-ray generator. Do not operate this X-ray generator except in accordance with these precautions, and any additional information provided by the X-ray generator manufacturer and/or competent safety authorities.

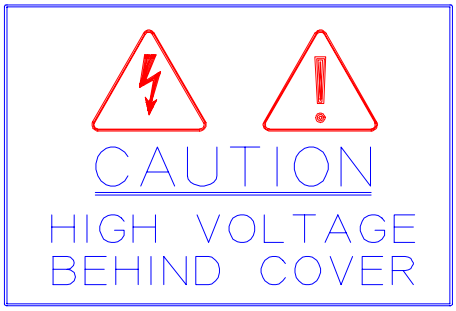
1B.4.1 Safety Warning Labels - Organization

The safety warning label information is organized into three subsections:

- Safety labels/notices common to Millenia and Indico 100
- Safety notices unique to Millenia
- Safety notices unique to Indico 100

1B.5.0 SAFETY LABELS / NOTICES COMMON TO MILLENIA AND INDICO 100

1B.5.1 Caution HV Behind Cover Label



MILLENIA: This label is attached to a cover over the main power contactor. This area will have mains voltage applied as long as the main disconnect is switched on.

MILLENIA: This label is attached to a cover over the resonant circuit and low speed starter components if a low speed starter is fitted. The resonant components (resonant capacitors etc) may be energized for 5 minutes after the console is switched off, or the main disconnect is switched off.

If a low speed starter is fitted, the associated components will have up to 240 VAC applied when the console is switched on.

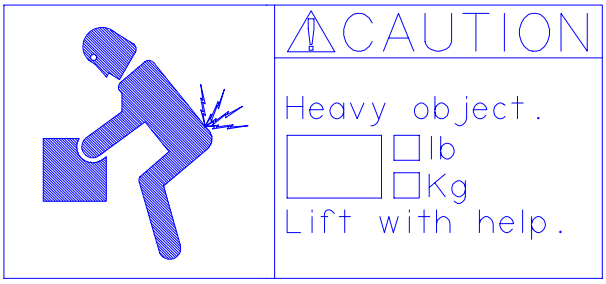
MILLENIA: This label is attached to each of the access panels on the rear of the generator. The high voltage hazards behind these panels is similar to that behind the upper and lower entrance doors, see 1B.7.4.

MILLENIA: This label is attached to a cover over the line adjusting transformer (if fitted). The terminals on the transformer will have mains voltage applied as long as the main disconnect is switched on. If access to the transformer connections is needed, SWITCH OFF THE MAIN DISCONNECT FIRST.

INDICO 100: This label is attached to a cover over the inverter board(s). The inverter assembly is connected to the main DC bus and will have high voltage applied at all times that the generator is switched on. This assembly will remain energized for 5 minutes after the generator is switched off, or the main disconnect is switched off.

INDICO 100: This label is attached to a cover over the main input fuses on the power input board. This area will have mains voltage applied as long as the main disconnect is switched on.

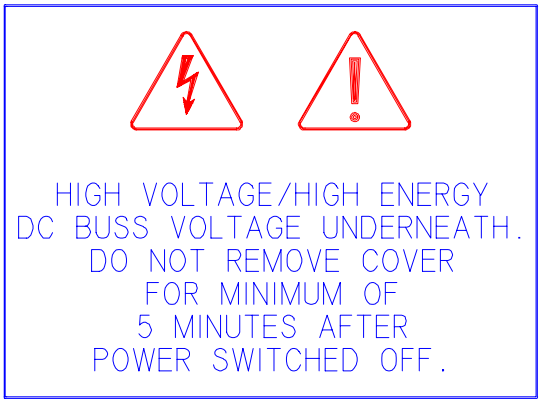
1B.5.2 Weight Label



MILLENIA: This label is attached to the upper and lower generator cabinets and to the HT oil tank and states the approximate weight of each of the generator sections and of the HT oil tank. This label cautions against attempting to lift those assemblies without proper assistance.

INDICO 100: This label is attached to the lower generator cabinet and to the HT oil tank and states the approximate weight of the lower generator cabinet and of the HT oil tank. This label cautions against attempting to lift those assemblies without proper assistance.

1B.5.3 DC Bus Label



MILLENIA: This label is attached to a cover over the DC bus capacitors. These capacitors will hold a lethal charge for 5 minutes after the console is switched off, or the main disconnect is switched off. Do not remove the cover for a minimum of 5 minutes after the power has been switched off.

INDICO 100: This label is attached to the removable panels on the lower (power supply) cabinet. The internal capacitors will hold a lethal charge for 5 minutes after the console is switched off, or the main disconnect is switched off. Do not remove the cover for a minimum of 5 minutes after the power has been switched off.

WARNING: ***WAIT A MINIMUM OF 5 MINUTES AFTER THE INPUT MAINS POWER HAS BEEN REMOVED BEFORE REMOVING ANY COVERS OR ACCESS PANELS. ONCE THE COVER(S) / PANEL(S) ARE REMOVED CHECK THAT THE VOLTAGE ACROSS THE DC BUS CAPACITORS IS LESS THAN 48 VDC BEFORE SERVICING.***

1B.5.4 Console CPU Board / Console Board

For 23 X 56 (cm) consoles: This symbol is printed on the console CPU board near U32.
HIGH VOLTAGE HAZARD: Approximately 400 VAC is present on this board in the area of U32 and J10. This voltage is used to light the backlight for the LCD display assembly in the console.
For 31 X 42 (cm) consoles: This symbol is printed on the console board near U40.
HIGH VOLTAGE HAZARD IF U40 IS FITTED: U40 is a high voltage source for the fluorescent backlight on the LCD display. Approximately 400 VAC is present on this board in the area of U40 and J10 if U40 is fitted. On LED backlight versions of the LCD display, high voltage source U40 is not fitted and no high voltage is present in this area.

1B.5.5 Generator Interface Board

This symbol is printed on the generator interface board in the high volage (mains) area.
HIGH VOLTAGE HAZARD: Components within the dashed line on the board have high voltage applied at all times that the main disconnect is switched ON. These components are live EVEN WITH THE CONSOLE SWITCHED OFF.

This symbol is printed on the generator interface board near fuses F1 to F6.
FUSE RATINGS:
F1: 1.6A 250V slow blow
F2, F5: 2.5A 250V slow blow
F3, F4: 5A 250V slow blow
F6: 2A 250 V slow blow

1B.5.6 Room Interface Board

This symbol is printed on the room interface board near the 110/220 VAC terminal blocks.
HIGH VOLTAGE HAZARD: 110/220 VAC may be present on this board at all times that the AC mains to the generator is switched on.

1B.5.7 AEC Board

This symbol is printed on some versions of AEC board with a high voltage power supply for a PMT or ion chamber.
HIGH VOLTAGE HAZARD: Depending on the AEC board type, up to approximately 1000 VDC may be present on the AEC board at all times that the generator is switched on.

1B.5.8 Power Input Board

Power input boards for single phase 240 VAC generators are fitted with several high power resistors that operate at temperatures sufficient to cause skin burn. Ensure that these resistors have cooled sufficiently after the power has been switched off before servicing.

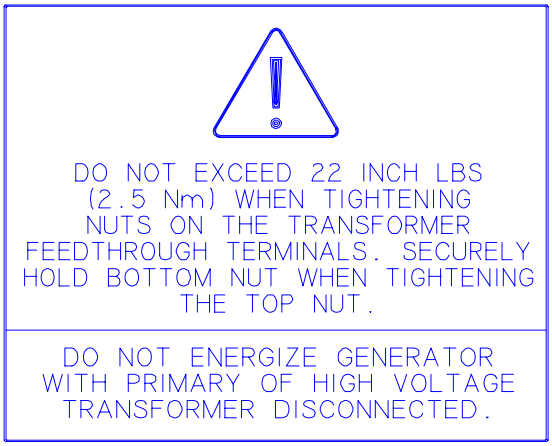
1B.5.9 Dual Speed Starter Board

This symbol is printed on the dual speed starter board if fitted.
HIGH VOLTAGE HAZARD: Approximately 600 VDC is present on this board. This voltage is supplied from the DC bus capacitors in the HF power supply. USE EXTREME CAUTION WHEN SERVICING, this voltage and current combination is lethal. Ensure that the DC bus capacitors are fully discharged before servicing as these capacitors will hold a lethal charge for 5 minutes AFTER THE EQUIPMENT IS SWITCHED OFF.

WARNING: ***COMPONENTS BEHIND VARIOUS COVERS, AS NOTED IN THIS SECTION, REMAIN LIVE EVEN WITH THE OPERATOR CONSOLE SWITCHED OFF. THE ONLY WAY TO REMOVE POWER FROM THESE AREAS IS TO SWITCH OFF THE MAIN DISCONNECT.***

1B.6.0 SAFETY LABELS / NOTICES UNIQUE TO MILLENIA

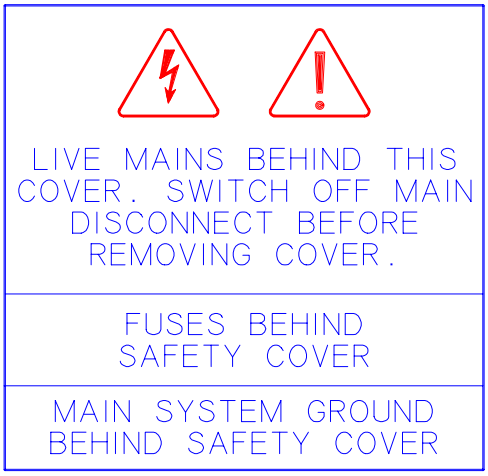
1B.6.1 HT Tank - Transformer Terminals Label



This label indicates that if the power supply inverter leads that attach to the high tension transformer primary terminals are not connected the generator must not be energized.

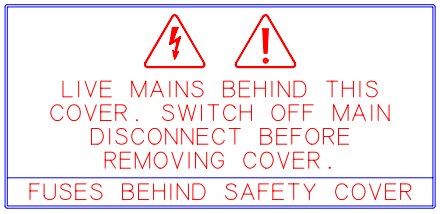
This label also cautions against over tightening the nuts on the transformer feedthrough terminals mentioned in the above paragraph.

1B.6.2 Live Mains / Fuses / Ground Label



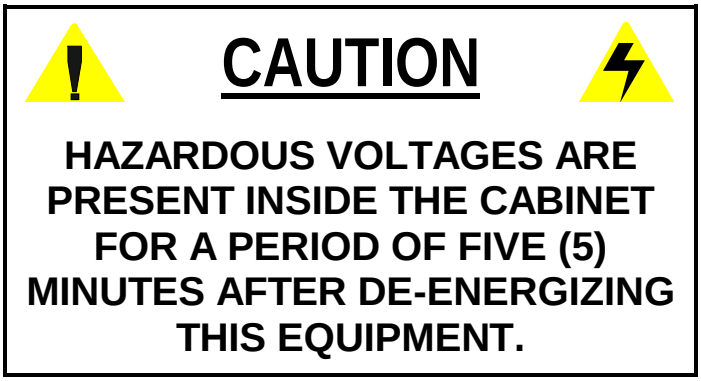
This label is attached to a cover over the main fuseblock and fuses. This area will have mains voltage applied as long as the main disconnect is switched on. The main system ground is also located behind this cover.

1B.6.3 Live Mains / Fuses Label



This label is attached to a cover over the fuseblock and fuses for the room interface transformer. This area will have mains voltage applied as long as the main disconnect is switched on.

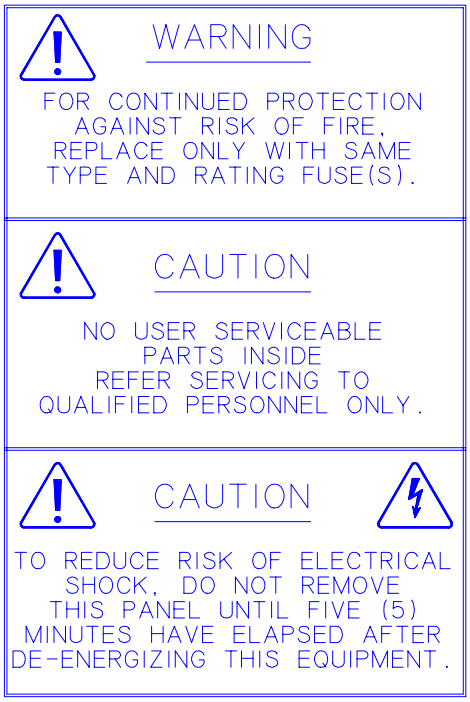
1B.6.4 Caution - Hazardous Voltages Label



This label is attached to the main access doors on the generator. ***Wait a minimum of five minutes after the main power has been removed from the generator before opening the cabinet doors***. This will allow for internal capacitors to discharge to a safe level.

The upper door provides access to the HV power supply driver section, room interface board and associated control circuits. The lower door allows access to the HT transformer, dual speed starter chassis if fitted, line adjusting transformer if fitted, and access to the tube stator connections and thermal switch connections. Additionally, the grounding location for the X-ray tube housing is located in this area. Hazards associated with each area within are outlined in the relevant sections of this chapter.

1B.6.5 Warning / Caution / Caution Label



This label is attached to a cover over the dual speed starter assembly (if fitted). DC bus voltage is present behind this panel, see 1B.5.9.

Ensure that the generator has been turned OFF for five minutes before removing the cover or disconnecting the DC supply.

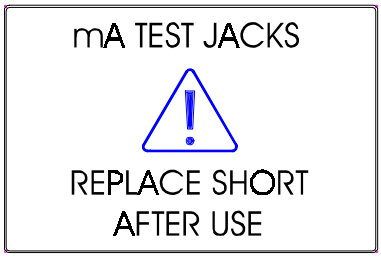
Replace fuses with the same type and rating, refer to spares list (chapter 8) for details.

1B.6.6 Tank Vent Label

This label is attached to the HT tank clamping bracket on generator models equipped with an HT tank vent screw. This screw must be loosened to allow venting of the HT tank before use of the generator when the tank is so equipped.

The screw must be fully tightened to prevent insulating oil spills or leaks from the HT tank during transportation or shipping.

1B.6.7 mA Test Jacks Label



This label is attached to the top of the HT tank on generator models equipped with mA test jacks. A similar warning is printed on tank lid boards using this connector, see 1B.7.8 below for details.

1B.6.8 mA test Jacks

This symbol is printed on tank lid boards with mA/mAs test jacks.
Replace the shorting jumper immediately after use. Do not attempt exposures without either the shorting jumper in place, or an approved mA/mAs measuring device properly connected.

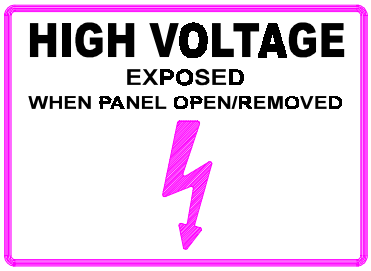
The warning “CAUTION: 48V MAX” printed on some tank lid boards does not apply in Millenia generator applications.

1B.6.9 F3 (Auxiliary Power Fuseblock)

This symbol is on a label under the fuseholder for F3 (to the right of the HF power supply).
FUSE RATING: 3A 500V slow blow.
This fuse is only used if the generator is fitted with the neutral block option.

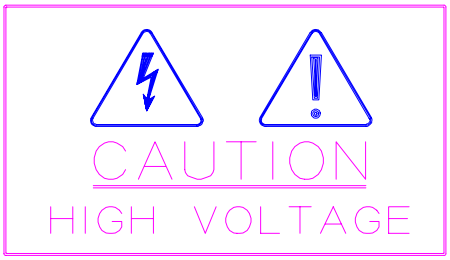
1B.7.0 SAFETY LABELS / NOTICES UNIQUE TO INDICO 100

1B.7.1 Caution HV Exposed Label



This label is attached to the removable panels on the lower (power supply) cabinet. High voltage is present within this cabinet at all times that the mains power is switched on.

1B.7.2 Caution HV Label



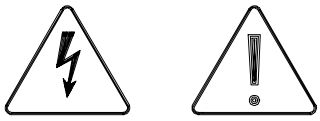
This label is attached to the power input board, and to the resonant board assembly. The input power board has line voltage components attached that will be live at all times that the main disconnect is switched on. This includes the input fuses, main line contactor, mains rectifier and associated components.

The resonant board assembly has components that may be energized at all times that the generator is on. These components may retain their charge for 5 minutes after the console is switched off, or the main disconnect is switched off.

1B.7.3 Danger HV Label

This label is attached to the primary terminals on the HT oil tank. These terminals may be energized at all times that the generator is switched on, and for 5 minutes after the console or the main disconnect is switched off.

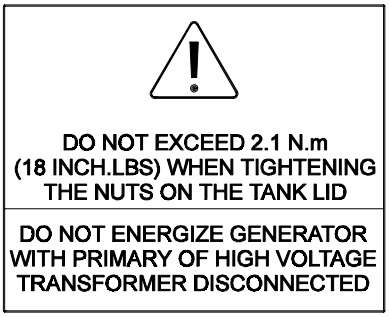
1B.7.4 High Voltage Warning Label



This label is attached to the inverter board(s) and to the low speed starter assembly if fitted. The inverter assembly is connected to the main DC bus and will have high voltage applied at all times that the generator is switched on. This assembly will remain energized for 5 minutes after the generator is switched off, or the main disconnect is off.

Components on the low speed starter assembly will have 240 VAC applied when the console is switched on.

1B.7.5 HT Tank - Transformer Terminals



This notice is printed on the HT oil tank lid and indicates that if the power supply inverter leads that attach to the high tension transformer primary terminals are not connected the generator must not be energized.

This notice also cautions against over tightening the nuts on the transformer feedthrough terminals mentioned in the above paragraph.

1B.7.6 Danger High Tension

This notice is printed on the HT oil tank lid. High voltage may be present at the primary terminals on the tank lid board, at the output high voltage connectors, and at the mA/mAs measuring jacks if the shorting link is opened for mA/mAs measurements.

CHAPTER 1 SECTION 1C

PREPARING FOR INSTALLATION

CONTENTS:

1C.1.0 INTRODUCTION

The following items must be considered before installing your generator:

- Power level of your generator.
- Power line requirements.
- Ground requirements.
- Physical placement of the generator.
- Environmental requirements for the generator.
- Cable runs from the generator to all room components: tables, buckys, X-ray tubes etc.

1C.2.0 GENERATOR POWER REQUIREMENTS

1C.2.1 30 kW Single Phase

Line Voltage	230 VAC ± 10%, 1∅.
Line Frequency	50/60 Hz.
Momentary Current	200 Amps.
Standby Current	5 Amps.

1C.2.2 37.5 kW Single Phase

Line Voltage	230 VAC ± 10%, 1∅.
Line Frequency	50/60 Hz.
Momentary Current	240 Amps.
Standby Current	5 Amps.

1C.2.3 30 kW Three Phase

Line Voltage	400 VAC ± 10%, 3∅ (for 400 VAC input generators). 480 VAC ± 10%, 3∅ with optional line adjusting transformer, (for 400 VAC input generators). 480 VAC ± 10%, 3∅ (for 480 VAC input generators). *** SEE NOTE AT THE END OF 1C.2.7**
Line Frequency	50/60 Hz.
Momentary Current	80 Amps/phase at 400 VAC. 67 Amps/phase at 480 VAC.
Standby Current	5 Amps.

1C.2.4 37.5 kW Three Phase

Line Voltage	400 VAC ± 10%, 3∅ (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ with optional line adjusting transformer, (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ (for 480 VAC input generators).
	*** SEE NOTE AT THE END OF 1C.2.7**
Line Frequency	50/60 Hz.
Momentary Current	95 Amps/phase at 400 VAC.
	75 Amps/phase at 480 VAC.
Standby Current	5 Amps.

1C.2.5 50 kW Three Phase

Line Voltage	400 VAC ± 10%, 3∅ (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ with optional line adjusting transformer, (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ (for 480 VAC input generators).
	*** SEE NOTE AT THE END OF 1C.2.7**
Line Frequency	50/60 Hz.
Momentary Current	120 Amps/phase at 400 VAC.
	100 Amps/phase at 480 VAC.
Standby Current	5 Amps.

1C.2.6 65 kW Three Phase

Line Voltage	400 VAC ± 10%, 3∅ (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ with optional line adjusting transformer, (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ (for 480 VAC input generators).
	*** SEE NOTE AT THE END OF 1C.2.7**
Line Frequency	50/60 Hz.
Momentary Current	150 Amps/phase at 400 VAC.
	120 Amps/phase at 480 VAC.
Standby Current	5 Amps.

1C.2.7 80 kW Three Phase

Line Voltage	400 VAC ± 10%, 3∅ (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ with optional line adjusting transformer, (for 400 VAC input generators).
	480 VAC ± 10%, 3∅ (for 480 VAC input generators).
	*** SEE NOTE AT THE END OF 1C.2.7**
Line Frequency	50/60 Hz.
Momentary Current	200 Amps/phase at 400 VAC.
	180 Amps/phase at 480 VAC.
Standby Current	5 Amps.

NOTE:** **THREE PHASE INDICO 100 GENERATORS ARE AVAILABLE IN 400 VAC AND 480 VAC MODELS. 400 VAC MODELS MUST BE OPERATED FROM 400 VAC MAINS, OR MAY BE OPERATED FROM 480 VAC MAINS WITH AN OPTIONAL LINE ADJUSTING TRANSFORMER. 480 VAC MODELS MUST BE OPERATED FROM 480 VAC MAINS (THESE ARE THE NOMINAL MAINS VOLTAGES, THE ALLOWED TOLERANCES ARE AS DETAILED IN THE PREVIOUS TABLES).

1C.2.8 Service Disconnect (All Models)

Refer to the following table for recommended service disconnect ratings.

1C.3.0 POWER LINE REQUIREMENTS

The following table defines the room power requirements for the generators.

> ***NOTE:*** ***THE FOLLOWING ARE TYPICAL VALUES AND ARE DEPENDENT ON CURRENT REQUIREMENTS AND LENGTH OF CABLE RUN***

Final selection of wire and disconnects must meet the requirements of the local electrical codes and is usually determined by hospital/contractor engineering.

AC Mains Cable Size: Distribution Transformer to Main Disconnect (AWG and mm^2)					**Disconnect to Generator (15 ft/5 m max)**	**Momentary Line Current**	**Service Rating**	**Distribution Transformer Rating**	**Ground Wire Size**	**Apparent Mains Resistance**
Mains Voltage	**50 ft (15 m)**	**100 ft (30 m)**	**150 ft (45 m)**	**200 ft (60 m)**						
30 kW 1∅ Generator										
230 VAC	#0000 (120 mm^2)	250MCM (150 mm^2)	300MCM (175 mm^2)	350MCM (200 mm^2)	#4 (25 mm^2)	200 A	100 A	45 kVA	#4 (25mm^2)	0.05 Ω
37.5 kW 1∅ Generator										
230 VAC	#0000 (120mm^2)	300MCM (175mm^2)	350MCM (200mm^2)		#4 (25 mm^2)	240 A	120 A	55 kVa	#4 (25mm^2)	0.04 Ω
30 kW 3∅ Generator										
400 VAC	#4 (25 mm^2)	#3 (30 mm^2)	#2 (35 mm^2)	#0 (50 mm^2)	#6 (15 mm^2)	80 A	60 A	45 kVa	#4 (25mm^2)	0.27 Ω
480 VAC	#4 (25 mm^2)	#3 (30 mm^2)	#2 (35 mm^2)	#0 (50 mm^2)	#6 (15 mm^2)	67 A	60 A	45 kVa	#4 (25mm^2)	0.40 Ω

AC Mains Cable Size: Distribution Transformer to Main Disconnect (AWG and mm^2)					Disconnect to Generator (15 ft/5 m max)	Momentary Line Current	Service Rating	Distribution Transformer Rating	Ground Wire Size	Apparent Mains Resistance
Mains Voltage	**50 ft (15 m)**	**100 ft (30 m)**	**150 ft (45 m)**	**200 ft (60 m)**						
37.5 kW 3∅ Generator										
400 VAC	#4 (25 mm^2)	#3 (30 mm^2)	#2 (35 mm^2)	#0 (50 mm^2)	#6 (15 mm^2)	95 A	100 A	55 kVA	#4 (25mm^2)	0.22 Ω
480 VAC	#4 (25 mm^2)	#3 (30 mm^2)	#2 (35 mm^2)	#0 (50 mm^2)	#6 (15 mm^2)	75 A	100 A	55 kVA	#4 (25mm^2)	0.32 Ω
50 kW 3∅ Generator										
400 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	120 A	100 A	70 kVa	#4 (25mm^2)	0.17 Ω
480 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	100 A	100 A	70 kVa	#4 (25mm^2)	0.24 Ω
65 kW 3∅ Generator										
400 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	150 A	100 A	85 kVa	#4 (25mm^2)	0.13 Ω
480 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	120 A	100 A	85 kVa	#4 (25mm^2)	0.19 Ω
80 kW 3∅ Generator										
400 VAC	#2 (35 mm^2)	#00 (70 mm^2)	#0000 (120 mm^2)	250MCM (150 mm^2)	#6 (15 mm^2)	200 A	100 A	100 kVa	#4 (25mm^2)	0.11 Ω
480 VAC	#2 (35 mm^2)	#00 (70 mm^2)	#0000 (120 mm^2)	250MCM (150 mm^2)	#6 (15 mm^2)	180 A	100 A	100 kVa	#4 (25mm^2)	0.15 Ω

1C.3.0 POWER LINE REQUIREMENTS (cont)

- All wiring and grounding should be in compliance with the national electrical code or equivalent.
- All wiring must be copper.
- For all installations, a separate copper ground cable #4 AWG (25 mm^2) is required from the building distribution ground to the ground terminal located inside the main disconnect switch fuse block.
- The disconnect switch shall be located within reach of the operator.

1C.4.0 GROUND REQUIREMENTS.

- A suitable flexible copper cable #6 AWG (15 mm^2) or larger must be supplied (usually part of the line cable) to connect from the disconnect switch to the main ground of the generator, located to the left of the main fuseblock on the power input board.
- A copper ground cable, #10 AWG (6 mm^2) or greater, from each X-ray tube's housing to be connected to the H.T. transformer's ground stud (located at the top of the HT transformer).
- If a neutral line is provided with the system under no circumstances is it to be used for ground purposes. The ground conductor must carry fault currents only.

1C.5.0 OUTLINE DRAWINGS

1C.5.1 Generator Outline

Refer to chapter 1A for the Indico 100 generator outline.

1C.5.2 Generator Shipping Containers: Dimensions

The overall dimensions of the Indico 100 shipping pack are shown below.

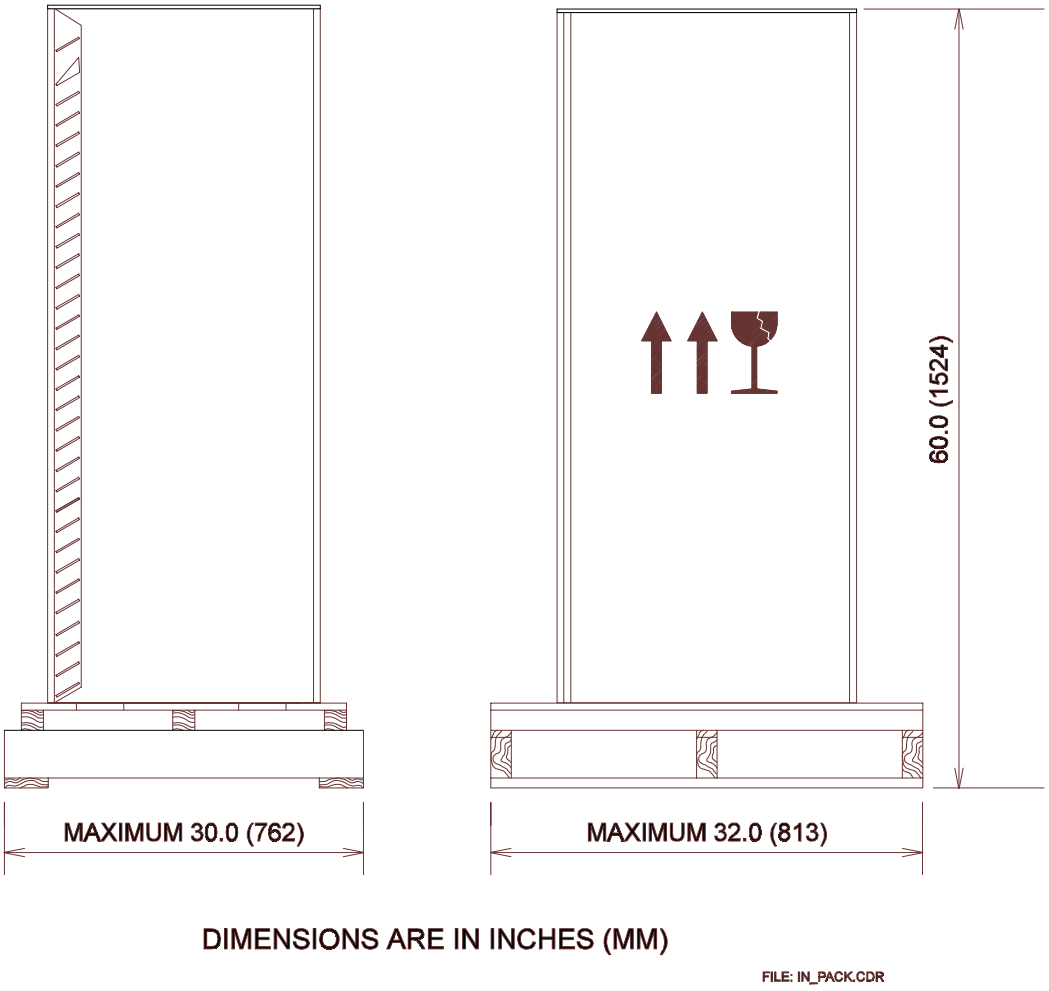


Figure 1C-1: Generator shipping container

1C.6.0 LOCATING THE GENERATOR CABINET AND CONTROLLER.

The generator cabinet is self standing and does not need to be supported. However, the installation should meet the following requirements:

- The floor must be flat and level.
- The floor must be capable of supporting a load of approximately 250 lbs (115 Kg).
- The generator installation area must be clean and free of dirt or debris.
- If required, the generator may be anchored to the floor via the hold-down brackets. See Figure 1C-2.
- Sufficient room must be provided to allow access to the rear and side panels for installation. Clearance must also be provided at both sides of the cabinet, at the front, and at the rear of the upper cabinet to allow access for service. See Figure 1C-3 for recommended clearances.
- A cable conduit should be provided from the control console to the generator cabinet to allow routing of the control cable if required. Allow for a 2 inch conduit. See Figure 1C-4.

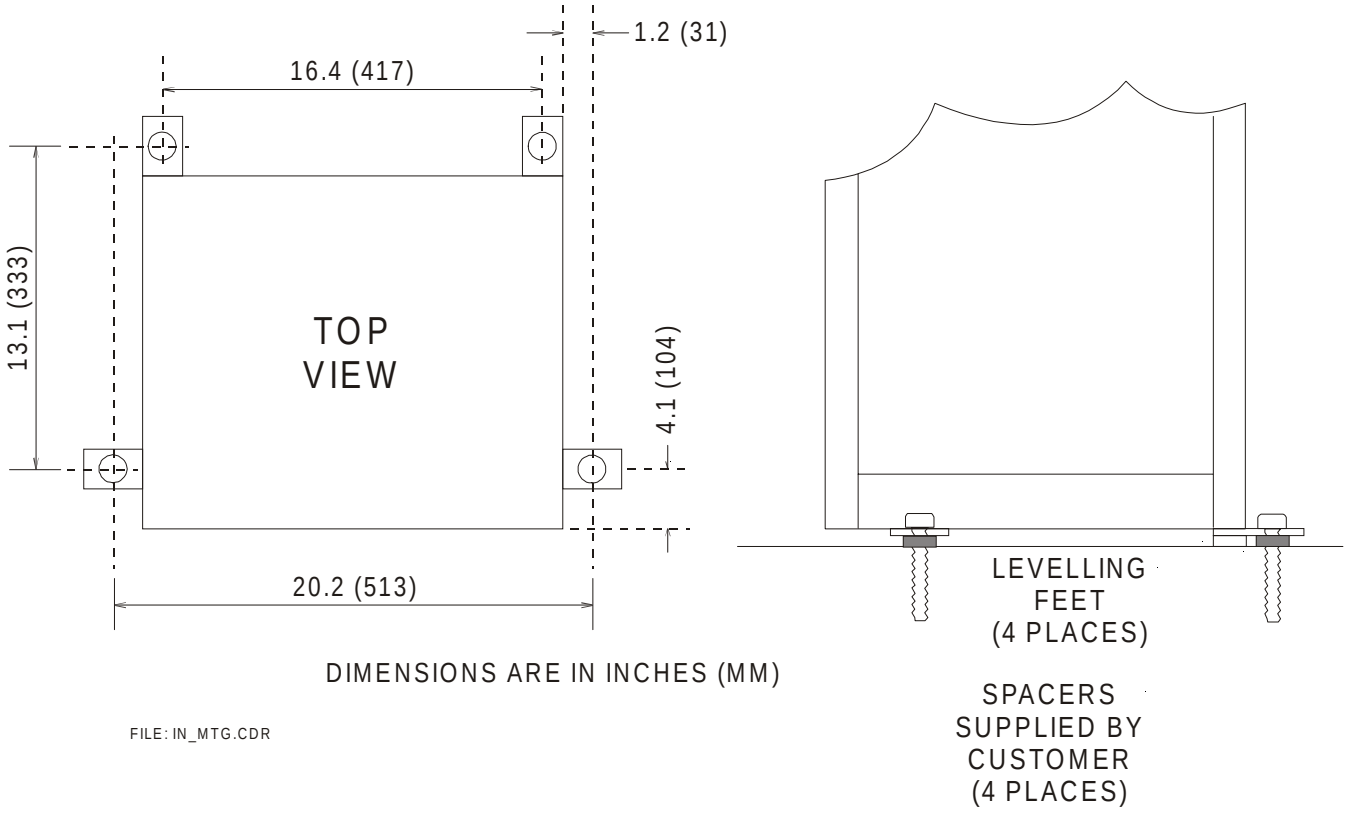


Figure 1C-2: Anchoring plates for securing the generator

1C.6.1 Locating The Equipment In The X-Ray Room.

Figure 1C-3 shows recommended clearances around the generator. Figure 1C-4 shows recommended clearances for through-the-wall cable routing.

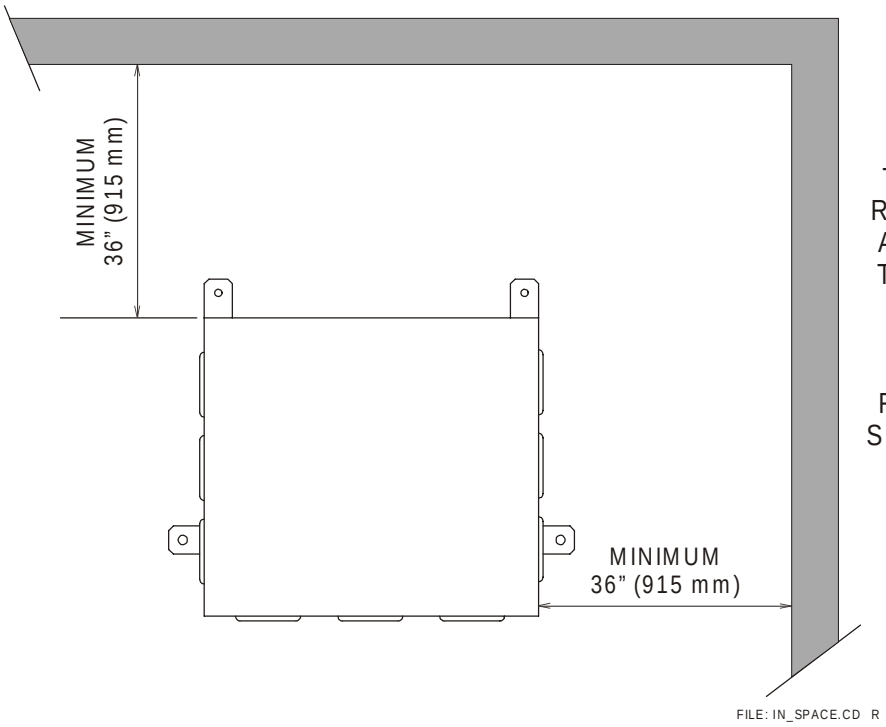


Figure 1C-3: Generator clearances

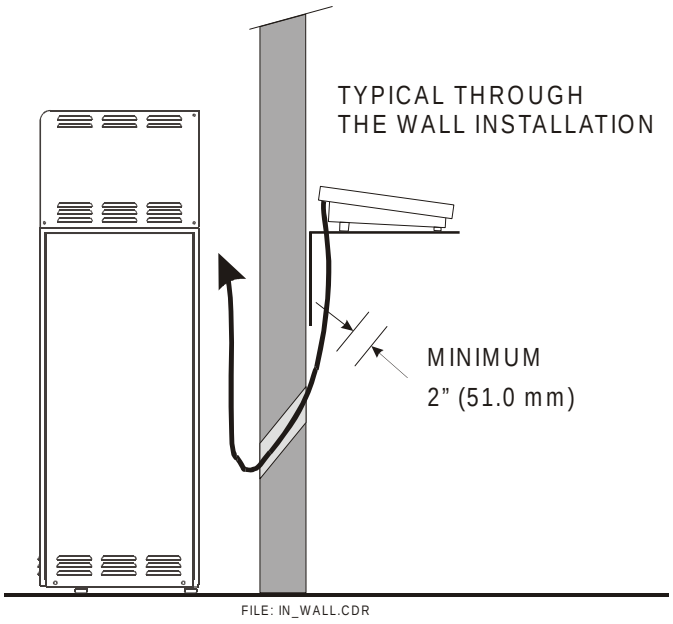


Figure 1C-4: Typical through the wall installation

1C.7.0 ENVIRONMENTAL REQUIREMENTS

Listed below are the ventilation requirements for the Indico 100 series generator:

- Unrestricted air flow must be provided at the front and sides of the cabinet, as well as underneath the unit.
- Do not allow storage on top of the cabinet.
- Typical heat output is 4000 BTU/hr (fluoro operation).
- Control console heat output is negligible (150 BTU/hr).

1C.8.0 CABLES SUPPLIED WITH THE INDICO 100 GENERATOR

Figure 1C-5 shows the cabling supplied with the generator:

- The cable supplied for the console is a 15 conductor cable with a standard length of 50 ft. (15 m).
- The cable supplied for the optional remote fluoro control is a 9 conductor cable with a standard length of 50 ft. (15 m).

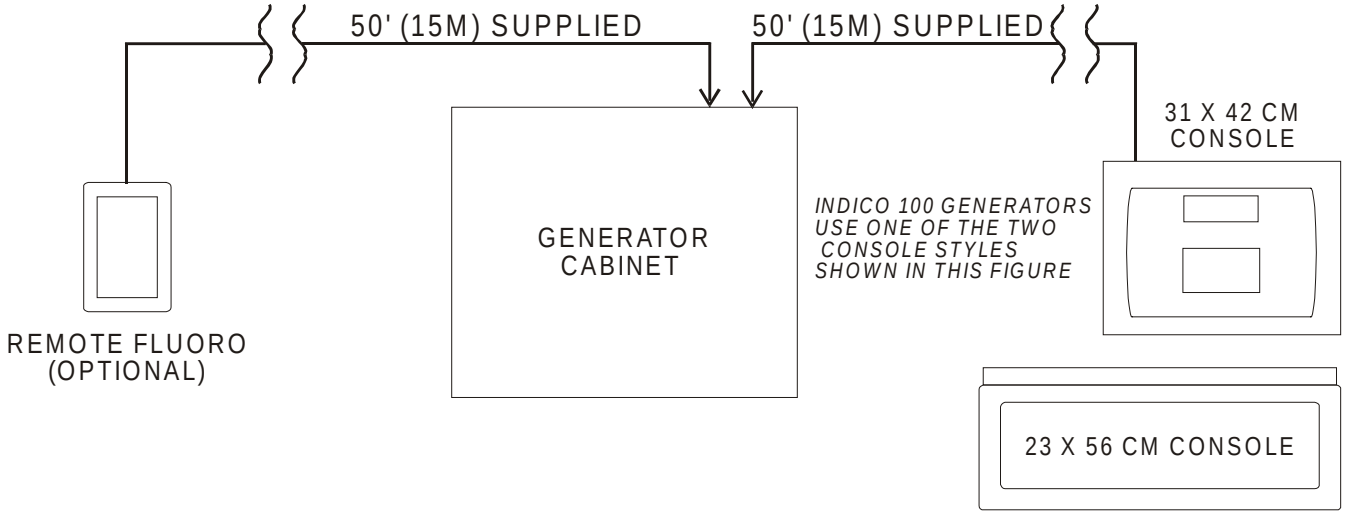


Figure 1C-5: Cabling supplied with generator

1C.9.0 PRE-INSTALLATION CHECK LISTS

The following checklists are provided to help the installer during a pre-installation site visit, prior to installing the generator:

- Site logistics
- Installation equipment

1C.9.1 Site Logistics

Before starting the generator installation, review the following checklist for site logistics.

CHECK √	DESCRIPTION
	Is there an unloading area to transport the generator from the delivery truck to the inside of the building?
	If the installation is not on the same floor as the delivery entrance, is there an elevator available?
	Are all halls and doorways large enough to allow the generator to pass through?
	Is there a transport dolly or similar device to move the Generator? It must have a minimum rating of 250 lb. (115 Kg.)
	Do any regulatory bodies need to be notified prior to installation?
	If movers are required, have arrangements for time and equipment been completed?
	Are lifting straps or some other suitable device available to lift the generator off the shipping pallet?

1C.9.2 Installation Equipment

The following is a checklist of recommended tools and test equipment for installation and calibration of the generator.

CHECK √	DESCRIPTION
	General handtools for installation: Wrenches, nut drivers, assortment of screwdrivers, pliers, etc.
	If the generator is to be anchored to the floor, suitable hardware and drills, drill bits etc must be available.
	A supply of connectors for wiring: lugs, caps, line splices etc.
	A calibrated DVM which indicates true RMS voltages.
	Dual trace memory oscilloscope with a minimum 20 MHz bandwidth; appropriate leads, probes, etc.
	Device for measuring true kVp and mA (mAs). This may be a Dynalyzer equivalent or a non-invasive system such as the Keithly TRIAD system.
	A calibrated radiation meter with detectors that will allow for R/min and uR type measurements (or uGy and Gy/min).
	A strobe or reed type tachometer to verify that the anode is rotating up to speed.
	A sufficient selection of patient absorbers to allow AEC and ABS calibration. A suggested selection is 3/4 inch Al (quantity 2); 1 mm of Cu (quantity 8), Water in containers of 5.0. 10.0, 15.0 cm thickness.
	Test phantoms to verify the imaging system with the generator.

CHAPTER 1

SECTION 1D

COMPATIBILITY LISTING

CONTENTS:

1D.1.0 INTRODUCTION

This section details external equipment which is compatible with your specific generator, and lists options which are included in that generator.

1D.2.0 COMPATIBLE DEVICES AND OPTIONS

The Millenia and Indico 100 family of generators may be factory or user configured to be compatible with various external devices. Certain features must be factory configured, others are user configurable. Please refer to chapter 2 and 3 of this manual and/or consult the factory for further specifics.

1D.2.1 X-Ray Tubes

Various makes and models of inserts and housings are supported.

CAUTION: ***PLEASE ENSURE THAT THE X-RAY TUBE INSERT IS AS STATED ON THE PRODUCT DESCRIPTION.***
IF THE HOUSING HAS BEEN RELOADED WITH ANOTHER INSERT TYPE, CALIBRATION MAY BE SERIOUSLY AFFECTED AND MAY CAUSE TUBE DAMAGE.

1D.2.2 Stators

Various types/impedances of stators are supported.

1D.2.3 AEC Devices

Various AEC devices (ionization, solid state or PMT) may be supported via the optional AEC board, depending on configuration.

1D.2.4 ABS Pickups

Various ABS pickups (light diode, composite video, PMT, etc) are supported on R&F generators depending on configuration.

1D.2.5 Tomographic Tables

Various. Please note that the generator is used as a backup timer ONLY in tomography.
AEC is NOT available for tomography.

1D.2.6 Digital Interfaces (R&F Generators)

The generator may be configured to be compatible with various digital imaging systems

1D.2.7 Options

Major options include AEC board, remote fluoro control unit, dual speed starter, line adjusting transformer, and two tube HT transformer.

NOTE: REFER TO THE PRODUCT DESCRIPTION AT THE END OF THIS SECTION FOR COMPATIBILITY OF YOUR SPECIFIC GENERATOR

1D.3.0 X-RAY TUBE DATA

PLEASE INSERT THE TUBE RATING CHARTS FOR THE X-RAY TUBES USED WITH THIS GENERATOR.

- **TUBE #1:**

  Type: _____

  Serial No.: _____

  Stator Type: _____

- **TUBE #2:**

  Type: _____

  Serial No.: _____

  Stator Type: _____

1D.4.0 CUSTOMER PRODUCT DESCRIPTION

The customer product description for this generator follows this page.

REPLACE THIS PAGE WITH

"CUSTOMER PRODUCT DESCRIPTION. PAGE 2”

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REPLACE THIS PAGE WITH

"CUSTOMER PRODUCT DESCRIPTION. PAGE 3”

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CHAPTER 1 SECTION 1E

GENERATOR LAYOUT AND MAJOR COMPONENTS

CONTENTS:

1E.1.0 INTRODUCTION

This section contains generator layout drawings and figures which identify the major generator components and circuit board Assemblies.

This section also shows the location and correct orientation of the power EPROM (located on the generator CPU board, the console EPROM (located on the console CPU board), and the dual speed starter EPROM (located on the dual speed starter board if the dual speed starter option is used). Refer to the applicable figures to ensure correct EPROM placement and orientation should EPROM replacement be necessary.

1E.2.0 MAJOR COMPONENT LAYOUT

1E.2.1 Generator Cabinet Assembly

The following major assemblies are located within the generator cabinet:

- Auxiliary power supply
- Generator control circuits
- Room interface for the X-ray system
- Low speed starter or optional dual speed starter
- High frequency inverter
- H.T. transformer
- Optional AEC board (automatic exposure control)

Figure 1E-1 shows the major components within the front and right side of the generator cabinet. Figure 1E-2 shows the major components accessible from the left side and the rear of the generator cabinet.

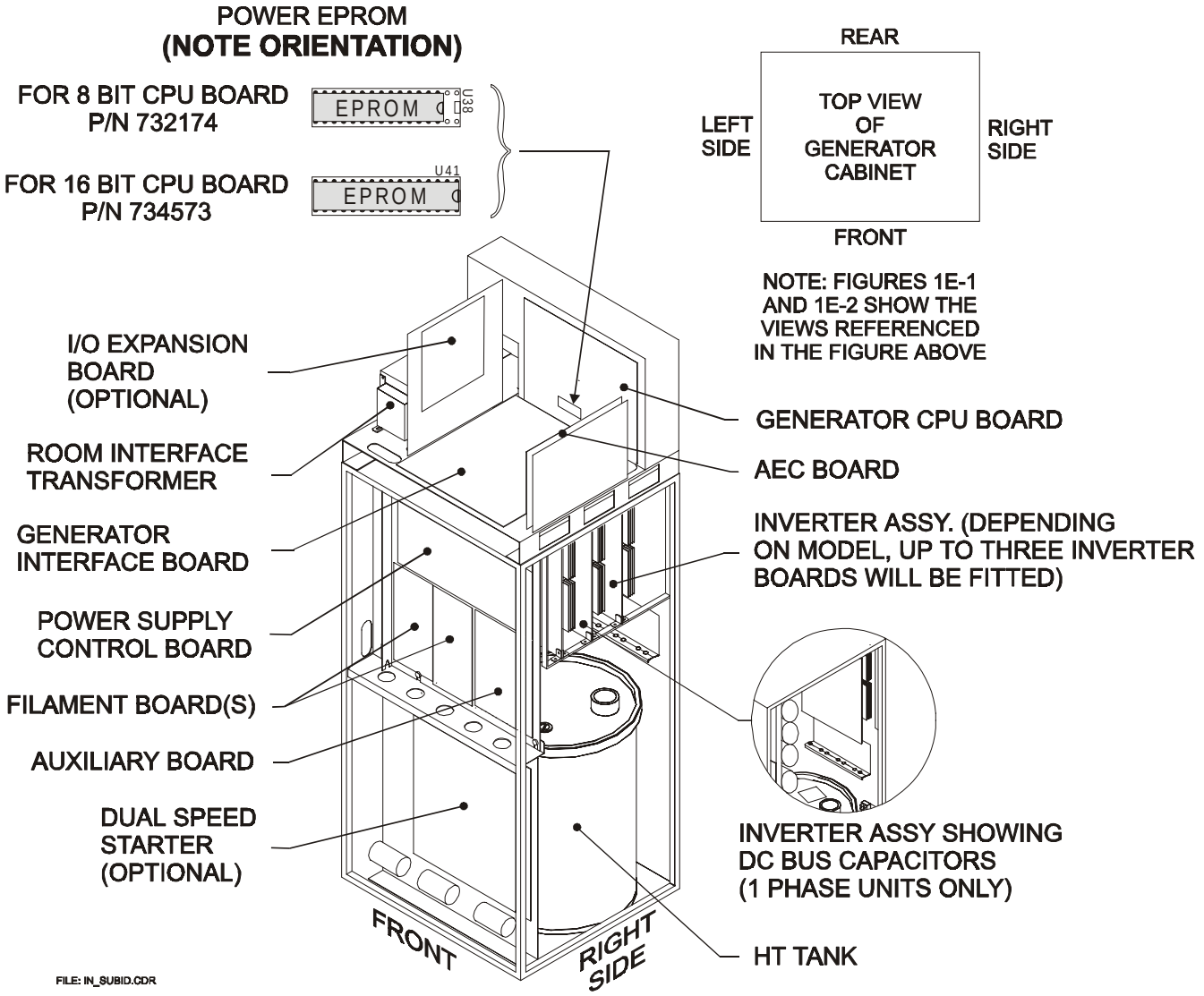

Figure 1E-1: Major generator subassemblies & power EPROM location

1E.2.1 Generator Cabinet Assembly (Cont)

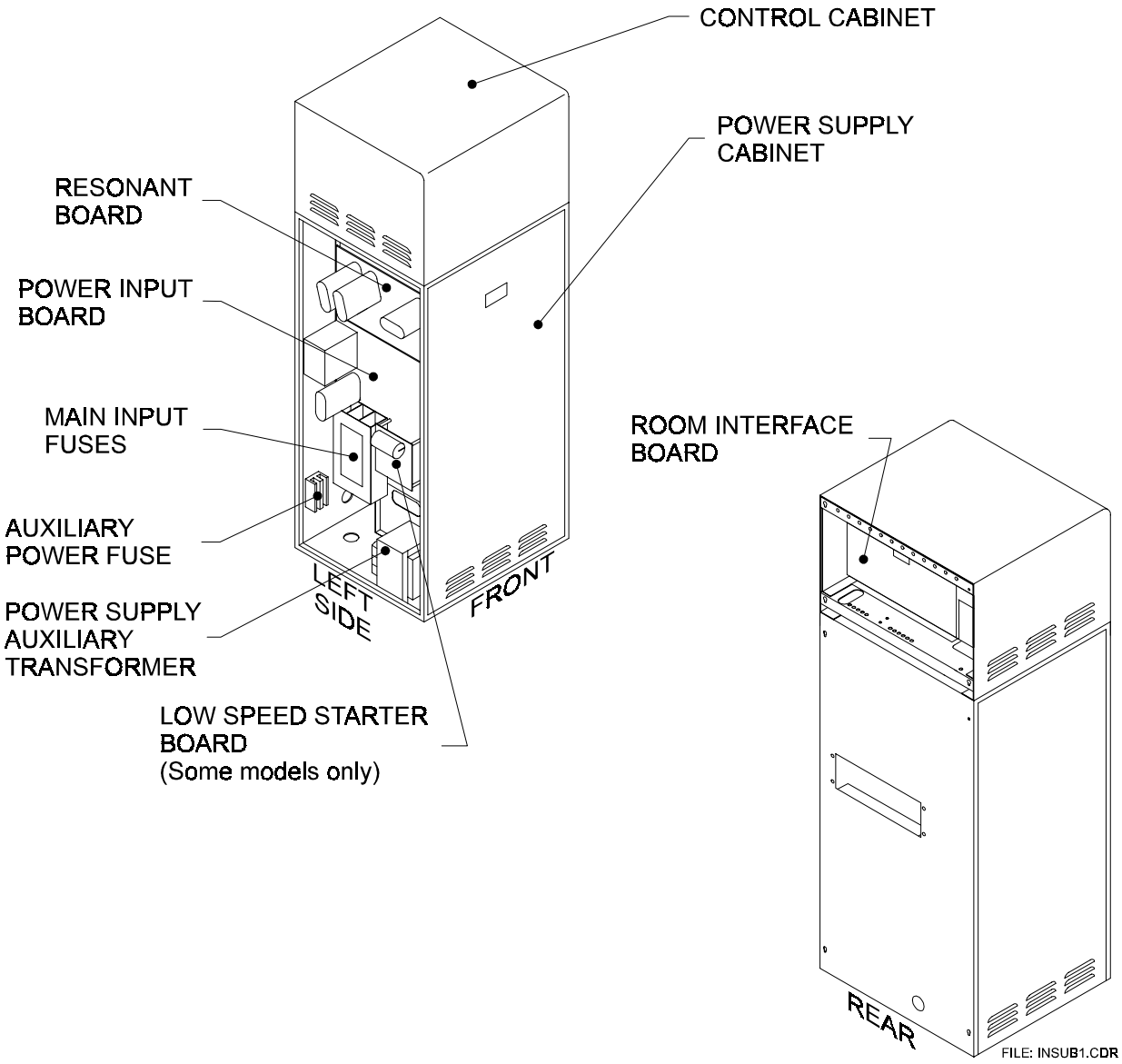

Figure 1E-2: Major generator subassemblies (right side and rear)

1E.2.2 Console Assembly

Figure 1E-3 is an overview of both the 23 X 56 cm console, and the 31 X 42 cm console styles for Indico 100 generators. Figure 1E-4 is an internal view of both of these console styles, showing the major components and cabling in the console assembly.

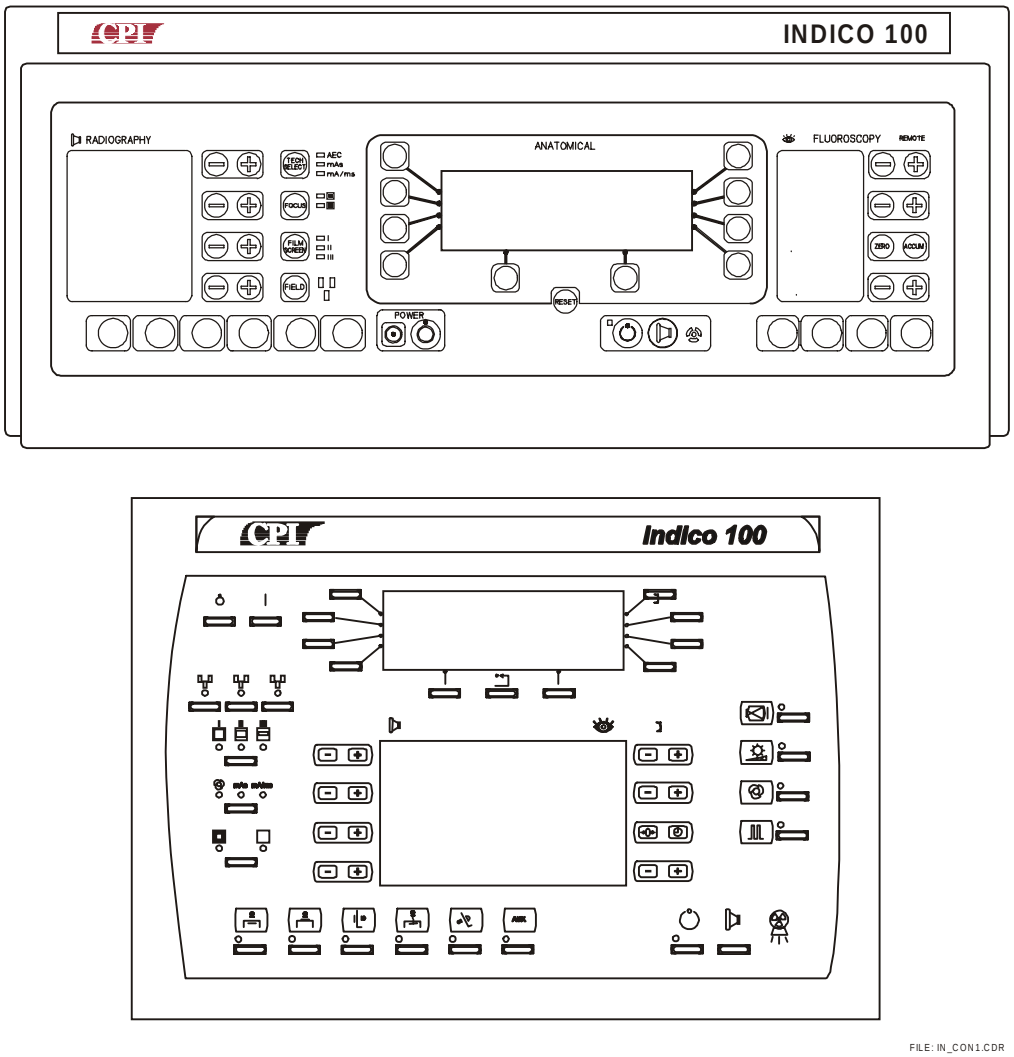

Figure 1E-3: Console top view

1E.2.2 Console Assembly (Cont)

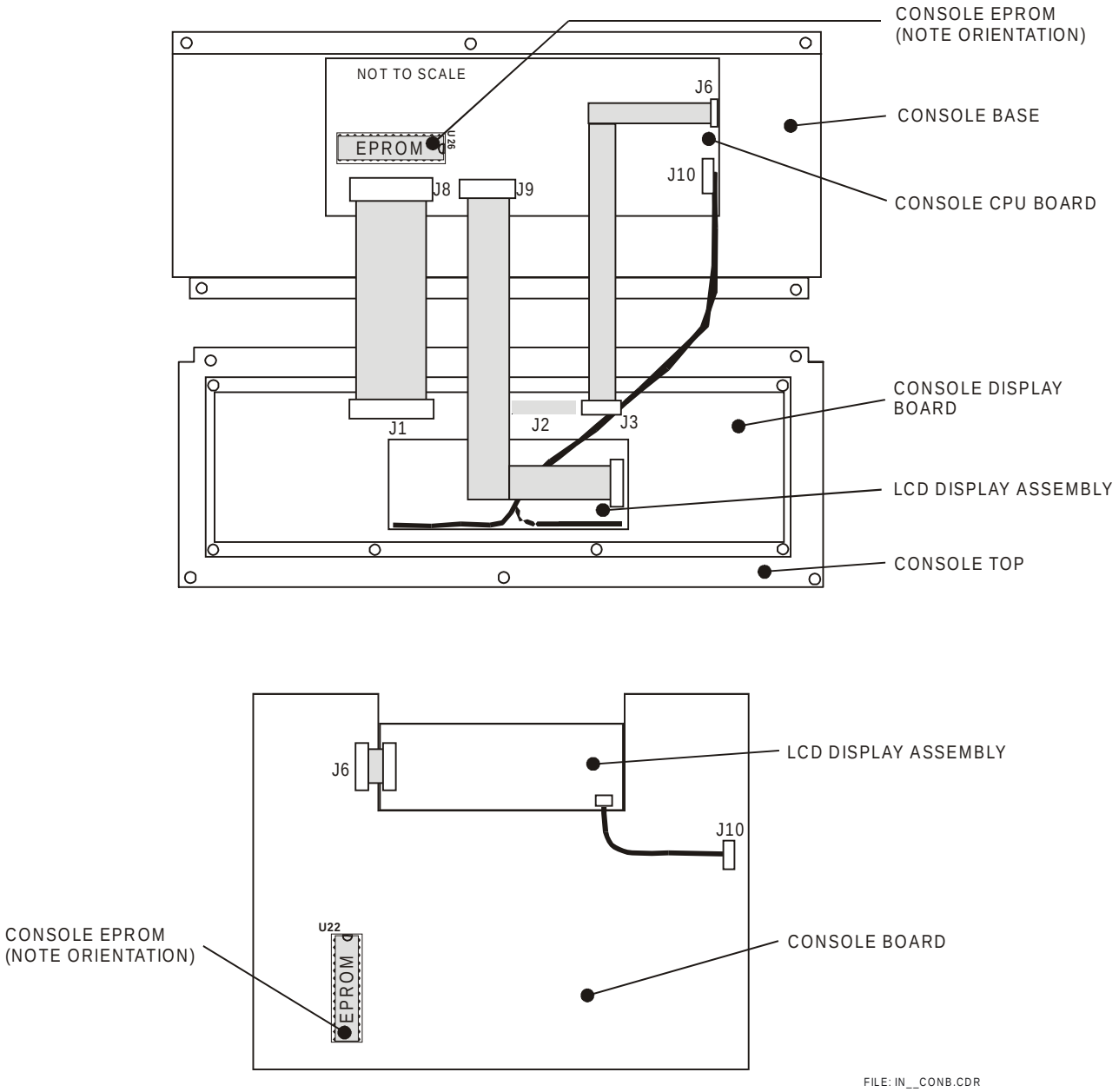

Figure 1E-4: Console internal view including EPROM location

1E.2.3 Remote Fluoro Control

Figure 1E-5 is an overview of the optional remote fluoro control for the Indico 100 generators. This allows operation of fluoro functions from a location other than the main console.

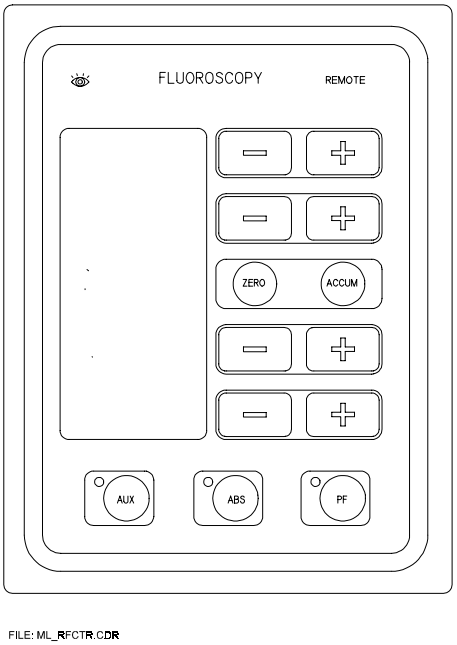

Figure 1E-5: Remote fluoro control unit overview

1E.2.4 Dual Speed Starter EPROM location

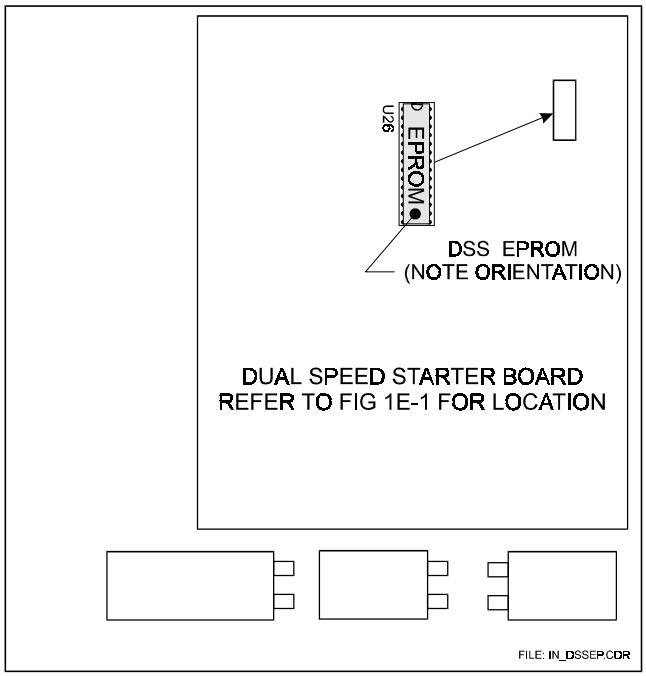

Figure 1E-6: EPROM location inside the dual speed starter

CHAPTER 2

INSTALLATION

CONTENTS:

2.1.0 INTRODUCTION

This chapter contains instructions for unpacking, positioning, and cabling the Indico 100 series of generators to allow initial operation and calibration. The instructions in this chapter allows the installation engineer to:

- Install the generator and control console.
- Install the optional remote fluoro control.
- Connect power.
- Calibrate one or two X-ray tube(s), depending on the generator model, ***without*** completing the room interface connections. This allows for simpler installation and troubleshooting on the generator itself.

2.2.0 RECEIVING

WARNING: ***THE INDICO 100 GENERATOR CONSISTS OF THE FOLLOWING ITEMS: UPPER AND LOWER CABINETS (FACTORY ASSEMBLED), CONTROL CONSOLE, AND AN OPTIONAL REMOTE FLUORO CONTROL.***

THE COMPLETE GENERATOR WEIGHS APPROXIMATELY 250 POUNDS (115 KG) IN ITS SHIPPING CONTAINER.

THE OPTIONAL LINE ADJUSTING TRANSFORMER IS SUPPLIED IN A SEPARATE ENCLOSURE, THE WEIGHT OF THAT ASSEMBLY IS APPROXIMATELY 100 POUNDS (45 KG).

THE OIL TANK IS LOCATED IN THE LOWER (POWER SUPPLY) CABINET. ONE PERSON SHOULD NOT ATTEMPT TO LIFT OR MOVE THE GENERATOR ASSEMBLY OR OPTIONAL LINE ADJUSTING TRANSFORMER WITHOUT ADEQUATE ASSISTANCE OR PROPER EQUIPMENT.

2.2.1 Major Shipping Assemblies

Refer to figure 1A-2 (chapter 1A). This shows the upper (control cabinet) and lower (power supply) cabinet fully assembled, along with the control console and optional remote fluoro control unit.

2.3.0 REMOVAL FROM PACK

1. Inspect the pack for evidence of shipping damage. If there is evidence of shipping damage, note this in the event that a damage claim is justified.

2. Locate any documentation attached to the outside of the cardboard sleeve. Be sure to read and understand this documentation before unpacking the generator. Then set this documentation aside temporarily until it can be transferred to a storage location close to the generator for future reference.

3. Remove the cardboard outer pack(s).

CAUTION: ***OPEN THE CARDBOARD PACK(S) CAREFULLY. SHARP TOOLS MAY DAMAGE THE CONTENTS.***

4. Set aside the cardboard pack(s).

5. Unscrew the bolts that secure the generator to the shipping pallet. Carefully lift the generator from the pallet. Refer to 2.3.1 for the procedure for lifting the generator.

6. Inspect for internal and external shipping damage. Refer to 2.4.0 for instructions for removing the external covers.

7. Unscrew the levelling feet at the bottom of the generator by a minimum of 1 1/2″ (35 mm). This will provide the required air flow underneath the generator cabinet and allow room to make levelling adjustments when the generator is placed in its final location.

8. Remove and unpack the control console, the optional line adjusting transformer if used, the optional remote fluoro control if used, and the optional handswitch kit if included, and check these items for any damage.

9. Remove and unpack the manuals and any other paperwork that may be packed with the generator.

10. Keep the shipping containers. In case of shipping damage, place the unit(s) back in its shipping pack and notify the carrier and the customer support group at CPI Canada Inc.

2.3.1 Lifting The Generator

One of the following methods is recommended for lifting or maneuvering the generator. Since the generator weighs more that 30 kg (65 lbs), proper lifting equipment should be used or additional help should be obtained to lift the unit. Refer to figure 1E-1 and figure 2-2 for identification of the panels referenced below.

- Lifting straps can be used along with a hoist to raise the generator. The straps should be placed underneath the generator cabinet and along the four sides to properly support the cabinet as it is raised.

- Remove the lower front access panel and the lower wiring access panel from the generator cabinet (refer to 2.4.0 - removing the external covers). The metal cross brace found at the front of the cabinet (below the circuit board mounting panel) may be used, in conjunction with the lip at the upper edge of the opening for the lower wiring access panel, as lifting points. Two people (one on each side) will be required to lift or maneuver the generator cabinet.

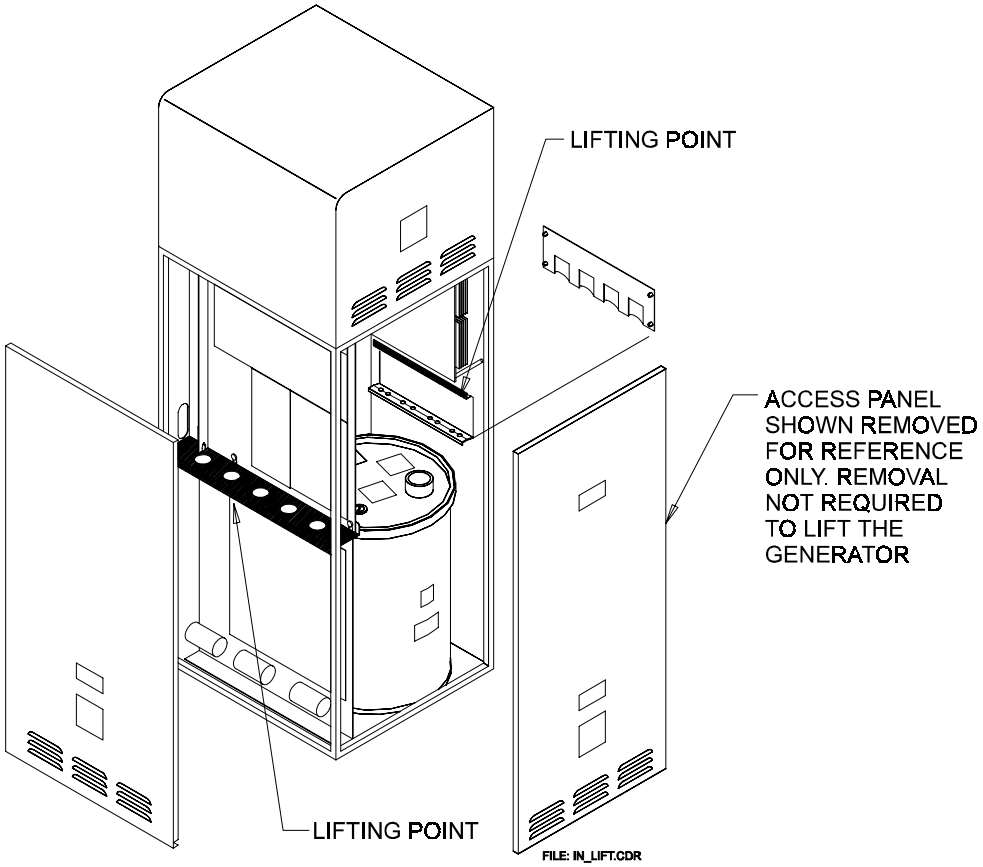

Figure 2-1: Generator lifting points

2.4.0 REMOVING THE EXTERNAL COVERS

NOTE: ***A POTENTIAL HAZARD EXISTS TO OPERATORS, SERVICE PERSONNEL, OR TO THE EQUIPMENT IF THE GENERATOR IS OPERATED WITH ANY OF THE GROUND LEADS TO THE EXTERNAL COVERS DISCONNECTED OR IMPROPERLY CONNECTED.***
BE SURE TO PROPERLY RECONNECT ALL GROUND LEADS AFTER COMPLETING ANY PROCEDURE THAT REQUIRES THEIR REMOVAL.

REFER TO FIGURE 2-2 FOR IDENTIFICATION OF COVERS/PANELS DESCRIBED IN THIS SECTION.

Lower Access Panels

Remove the two screws at the bottom of the panel to be removed. Carefully lower the panel such as to allow the locating tabs at the top of the panel to clear the slots in the lip of the frame. The panel may then be lifted away from the frame.

If it is required to temporarily remove the ground wire connected to the panel, remove the nut that secures the ground lead to the cabinet frame and then disconnect the ring terminal.

Reverse the above steps to reconnect the ground wire(s), and to reinstall the access panel(s).

Lower Wiring Access Panel

THIS PANEL IS NOT FITTED IF THE OPTIONAL WIRING CHANNELS ARE USED.

Remove the screw from the upper right hand corner of the panel. Pull out the snaps on the three nylon fasteners such as to release the panel. Remove the panel from the generator.

Upper Wiring Access Panel

THIS PANEL IS NOT FITTED IF THE OPTIONAL WIRING CHANNELS ARE USED.

Pull out the snaps on the two nylon fasteners, then remove the screws from the upper left hand and upper right hand corners of the panel. Remove the panel from the generator.

If it is required to temporarily remove the ground wire connected to the panel, remove the nut that secures the ground lead to the access panel and then disconnect the ring terminal.

Reverse the above steps to reconnect the ground wire(s), and to reinstall the access panel(s).

2.4.0 REMOVING THE EXTERNAL COVERS (Cont)

Upper Cabinet Hood

Most adjustments and servicing of the generator can be done by flipping back the hood. It is rarely necessary to completely remove the hood. However, both procedures are detailed below:

Flipping back the hood

Remove the upper wiring channel if fitted. The procedure for doing this is detailed later in this subsection. Remove screws **A** and **B** (shown in figure 2-2) on both sides of the hood. Loosen screw **C** on both sides of the hood by 1-2 turns.

Lift up on the front of the hood, allowing the hood to pivot on screws **C**. The hood should be supported when flipped open such that the hood does not exert excess pressure on the back of the cabinet.

Removing the hood

With the hood flipped back, disconnect the ground wire at the base of the upper cabinet by removing the nut on the cabinet frame that secures the ground lead, and then disconnecting the ring terminal that secures the ground lead. Lower the hood back to its normal position and remove the two upper screws (**C** in figure 2-2). Firmly grip the sides of the hood and slide the hood away from the rest of the cabinet.

Be sure to properly re-connect the ground lead when the hood is replaced.

Upper & Lower Wiring Channels

The wiring channels are optional. If the wiring channels are fitted, the upper and lower wiring access panels will not be used.

Upper wiring channel

Refer to the instructions for removing the UPPER WIRING ACCESS PANEL on the previous page.

Lower wiring channel

Remove the screw from the upper left hand and upper right hand corners of the panel. Then slide the wiring channel up such that the shoulder rivets clear the keyhole slot at the bottom of the cabinet. The lower wiring channel may then be removed from the generator.

2.4.0 REMOVING THE EXTERNAL COVERS (Cont)

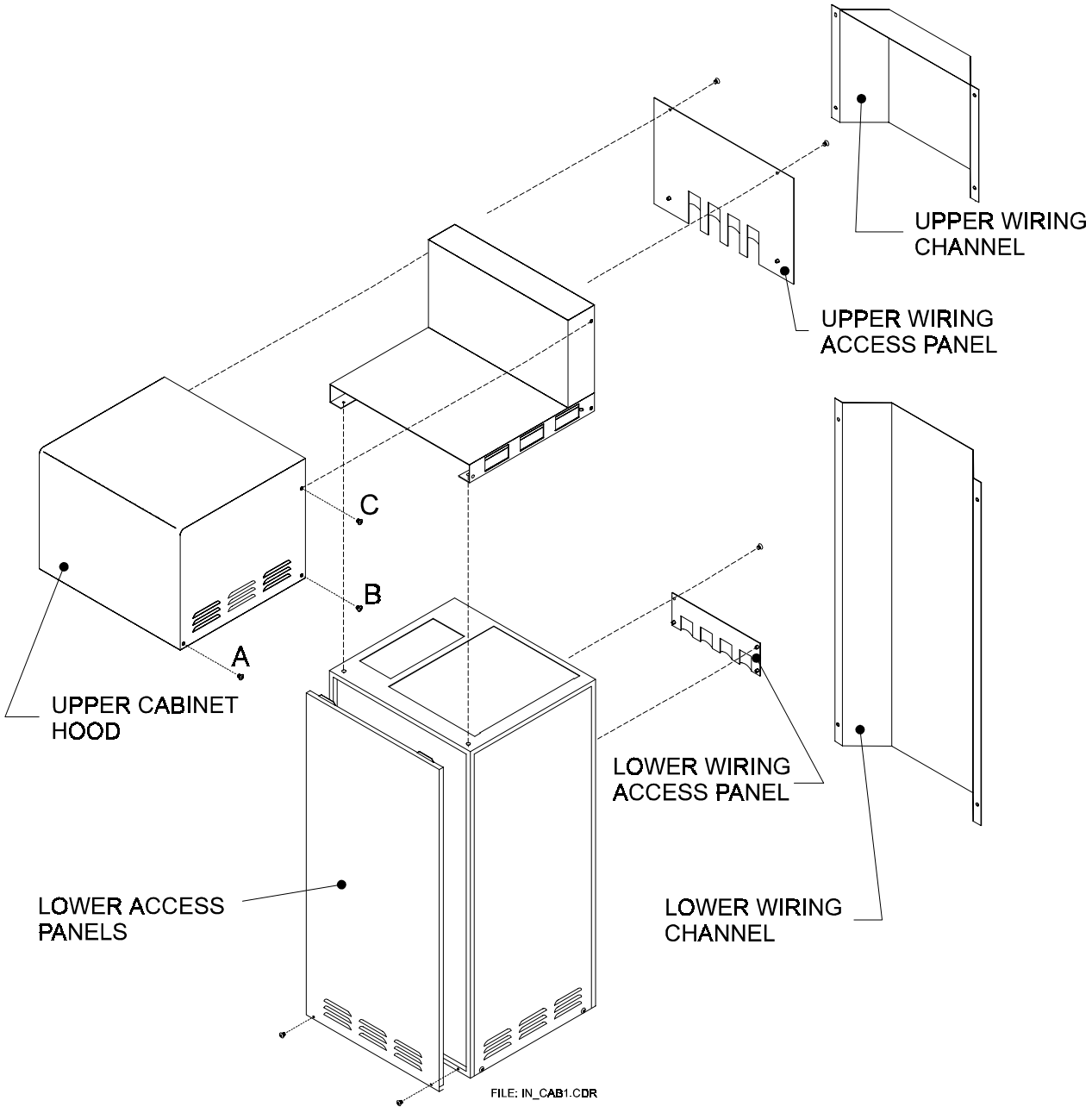

Figure 2-2: Removable external covers on generator cabinet

2.5.0 LINE ADJUSTING TRANSFORMER

An optional line adjusting transformer is available if required to allow 480 VAC generators to operate from 400 VAC mains, or to allow 400 VAC generators to be operated from 480 VAC mains. The line adjusting transformer is supplied in a separate enclosure. Please consult the factory for further details regarding this option.

2.6.0 MAJOR COMPONENT LAYOUT

Refer to chapter 1E for major component identification and layout.

2.7.0 INSPECTING THE HT TANK

Before continuing with the installation of the generator, the HT oil tank should be inspected as per the following steps:

- Verify that there is no obvious shipping damage to the tank (i.e. dents to the tank surface).
- Carefully check the inside of the generator cabinet and the HT tank for evidence of any oil loss. Refer to chapter 6 if it is suspected that there has been some loss of oil.
- Verify that the clamps supporting the HT oil tank are tight.
- Verify that all the connections to the tank lid are secure.
- Verify that the rubber vent plug on the top of the tank is snug.

2.8.0 EQUIPMENT PLACEMENT

2.8.1 Equipment Cabinet

Place the equipment cabinet in a location that will allow the following:

- Easy front and side access for service and sufficient clearance at the rear for room interface cables. Refer to chapter 1C.
- Air circulation - a minimum height of 1 1/2″ (35 mm) is recommended to allow airflow underneath the generator.
- Stable footing - the leveling feet at the bottom of the cabinet will be used to prevent movement during normal operation.
- Close proximity to service disconnect boxes - cables should not be on the floor where they could be stepped on.

2.8.2 Control Console

Locate the control console in its intended position and ensure that it is stable. Refer to chapter 1C:

- If the console is located on a shelf, supply index pins or equivalent hardware to the base of the console to prevent slipping.
- Ensure that the console is mounted at a height and angle to allow easy viewing of the displays.
- If the optional CPI pedestal stand is to be used for the console mounting, follow the mounting instructions supplied with the stand.
- Leave sufficient slack in the cabling to the console to allow for future service and maintenance.

2.8.2 Control Console (Cont)

NOTE: ***DO NOT LOCATE THE CONTROL CONSOLE WHERE X-RADIATION MAY BE PRESENT DURING INSTALLATION OR OPERATION.***

YOU MAY CHOOSE TO TEMPORARILY LOCATE THE CONSOLE NEAR TO THE GENERATOR FOR INITIAL PROGRAMMING AND CALIBRATION. IF THIS IS SO, PLEASE COMPLETE THE FINAL CONSOLE INSTALLATION PER THIS SECTION WHEN THE GENERATOR INSTALLATION IS COMPLETED.

2.8.3 Anchoring The Generator To The Floor

If it is desired to anchor the generator to the floor, refer to chapter 1C. This should not be done until all cable hookups are completed which require rear access to the generator.

2.8.4 Leveling

Adjust the leveling feet such that the generator is level and stable. This adjustment must be made for both anchored and free-standing generator installations. As noted in 2.3.0, the leveling feet must be unscrewed by a minimum of 1 1/2″ (35 mm) to allow for proper air flow underneath the generator.

2.9.0 WIRING TO THE GENERATOR

2.9.1 Control Console

1. Connect the 15 conductor console cable from J5 at the rear of the console to J4 of the generator interface board. Ensure that the screw locks are fully tightened to secure the connectors. Refer to figure 2-11 for the location of J4 on the generator interface board.

2. Connect a separate ground wire, #14 AWG (2.3 mm^2) or larger, from the ground stud on the rear of the console (marked CONSOLE GROUND in figure 2-3) to the ground stud located to the left of the main fuse block on the power input board. This is marked GROUND in figure 2-7.

3. Figure 2-3 shows the designations and functions of the connectors on the rear panel of the 23 X 56 (cm) and the 31 X 42 (cm) control console.

Do not connect unapproved equipment to the rear of the console. For the 23 X 56 (cm) console, J5 is used for the interconnect cable to the generator main cabinet, J4 is not used, J2 is a serial port for use by an external computer, and J1 is for connection of an optional printer.
For the 31 X 42 (cm) console, J5 is used for the interconnect cable to the generator main cabinet, J2 is a serial port for use by an external computer, and J13 is for connection of an external hand switch and / or foot switch. **INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE**.

2.9.1 Control Console (Cont)

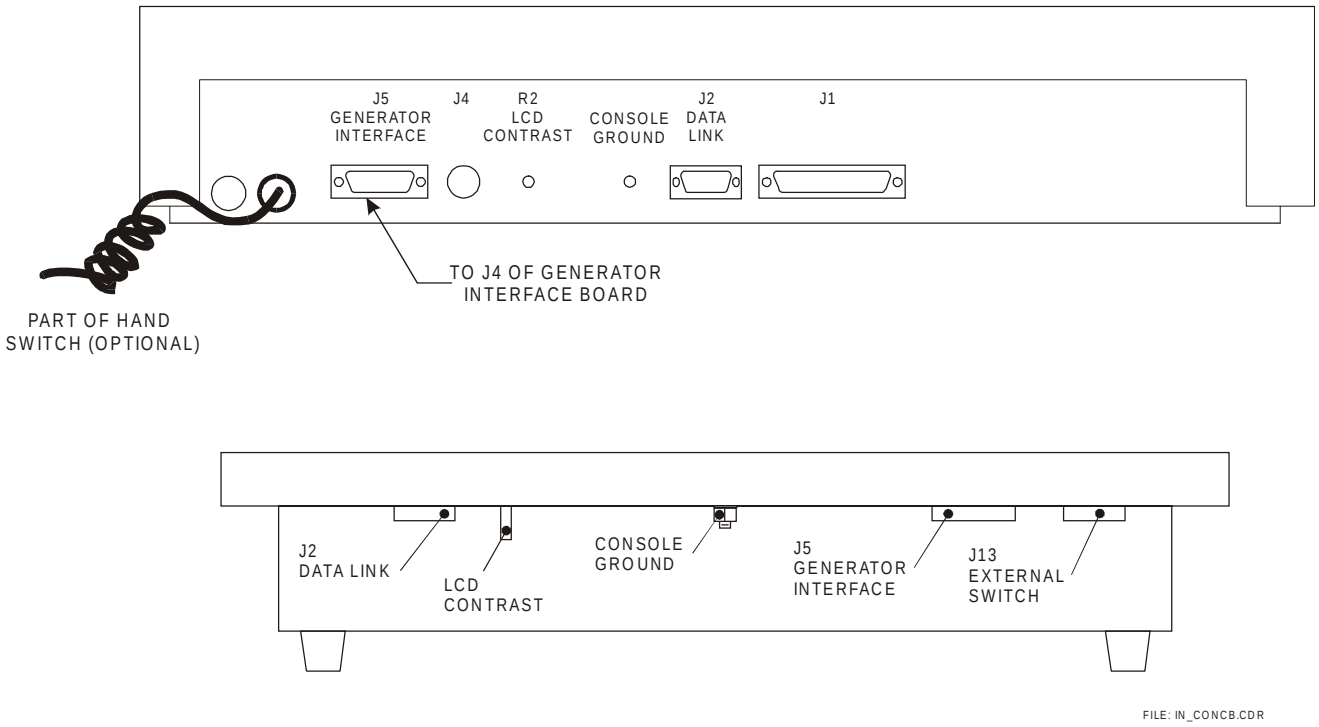

Figure 2-3: Rear of control console

2.9.2 Remote Fluoro Control (Optional)

1. Connect the free end of the 9 conductor remote fluoro cable (from the optional remote fluoro control box) to J11 of the generator CPU board. Ensure that the screw locks are fully tightened to secure the connector. Refer to figure 2-4 for the location of J11 on the generator CPU board.

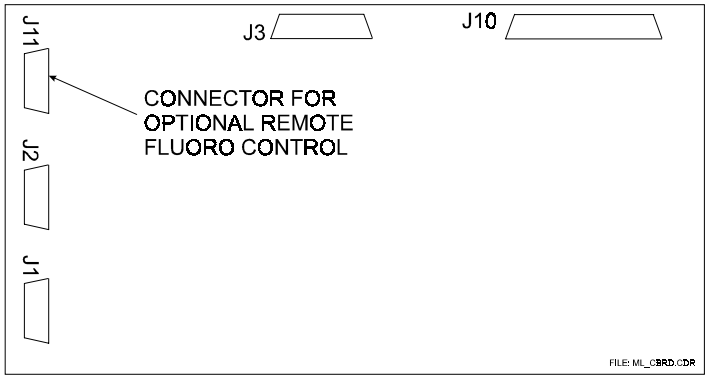

Figure 2-4: Remote fluoro connector on generator CPU board

2.9.3 Hand Switch Installation

FOR 23 X 56 (CM) CONSOLES: The optional hand switch is supplied as a kit which must be user installed. If this option is used, refer to separate installation instructions packaged along with the hand switch.

For reference, a drawing is supplied in this section showing the hand switch connections to the console CPU board. See figure 2-5.

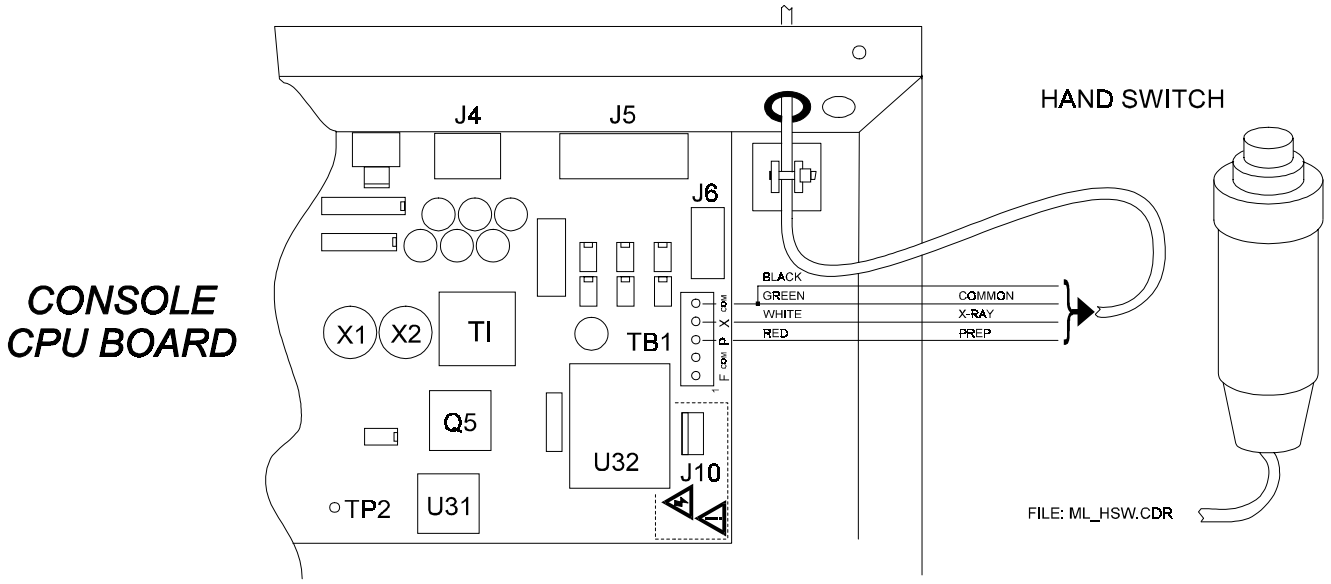

Figure 2-5: Hand switch connections on console CPU board

FOR 31 X 42 (CM) CONSOLES: The optional hand switch, if ordered from CPI Canada Inc, is supplied pre-wired to a male 9 pin subminiature 'D' connector. This connects to J13 on the rear of the console. Fluoro foot switch connections may also be made to this connector. The table below shows the pin designations for J13. A male 9 pin subminiature 'D' connector will need to be provided by the installer if the CPI supplied hand switch is not used.

J13 PIN NUMBER	DESCRIPTION
1	Hand Switch: X-Ray
2	No Connection
3	Hand Switch: Prep
4	No Connection
5	Hand Switch: Common (ground)
6	No Connection
7	Foot Switch: 'live' terminal
8	No Connection
9	Foot Switch: 'ground' terminal

2.9.4 X-Ray Tube Stator & Thermal Switch Connections

Refer to figure 2-6 for the X-ray tube stator and thermal switch connections.

1. Route the X-ray tube stator cable(s) through the lower wiring access panel panel on the rear of the generator cabinet, then route the cables towards the stator terminal blocks as shown in the figure below.

   FOR UNITS WITH A LOW SPEED STARTER, SHIELDED STATOR CABLES ARE RECOMMENDED. FOR UNITS WITH A DUAL SPEED STARTER, SHIELDED STATOR CABLES MUST BE USED.

   THE SHIELD FOR THE STATOR CABLE(S) MUST BE PROPERLY GROUNDED AT THE CHASSIS GROUND STUD(S) SHOWN IN FIGURE 2-6.

2. Connect the wires to the appropriate terminal as shown. The tube thermal switch will normally be connected to the THERMAL SWITCH connections on the stator terminal block, but may optionally be connected to the room interface board (refer to chapter 3B).

3. Ensure that all terminal connections are tight, then dress and secure the cables.

NOTE: ***ONE TUBE ONLY GENERATORS WILL HAVE 1 STATOR TERMINAL BLOCK FITTED. THE LOWER TERMINAL BLOCK IN FIGURE 2-6 IS ONLY FITTED ON TWO TUBE GENERATORS.***

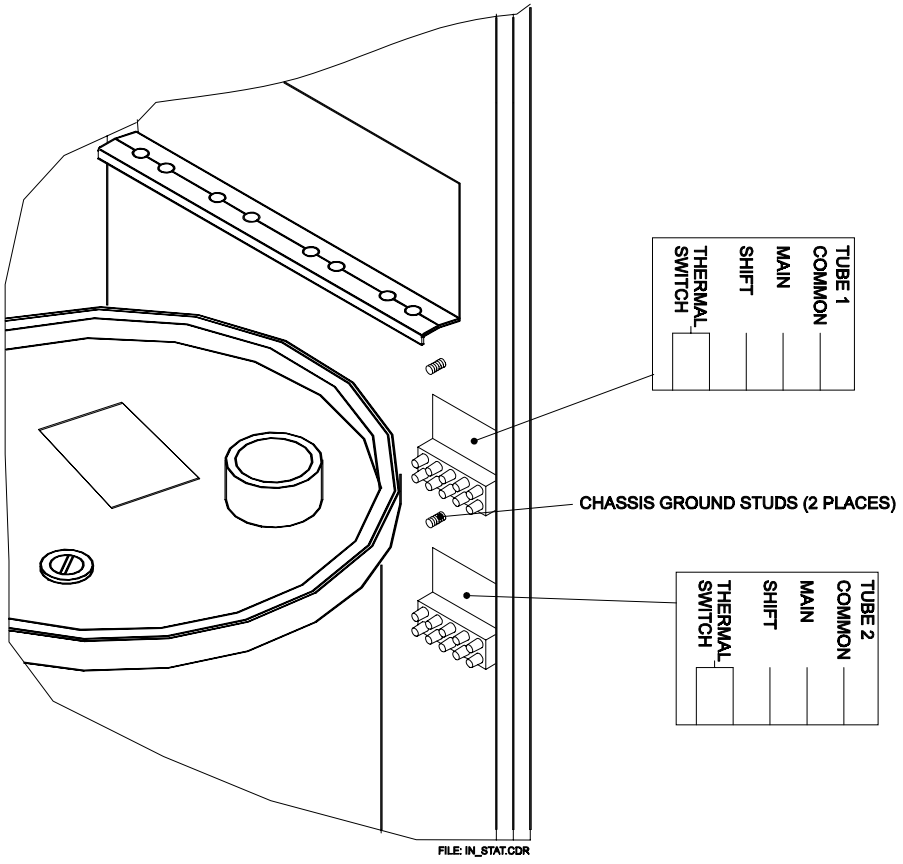

Figure 2-6: Stator connections to generator

2.9.5 Generator Mains Connection

WARNING: ***TO AVOID ELECTRICAL SHOCK, ENSURE THAT THE AC MAINS DISCONNECT IS LOCKED IN THE OFF POSITION, AND THAT ALL MAINS CABLES ARE DE-ENERGIZED BEFORE CONNECTING TO THE GENERATOR.***

Refer to chapter 1C for generator power and generator power line requirements.

1. Pass the AC mains cable through the access hole located at the lower rear of the generator.

2. Use an appropriate cable clamp to secure the mains cable at the cabinet entrance.

3. Temporarily remove the safety cover from the main fuses. Strip sufficient cable jacket to allow the ground wire to reach the main ground connector located at the left side of the main fuse block. Refer to figure 2-7.

4. Connect the ground wire to the chassis ground connector, and connect the mains wires to the terminals on the bottom of the main fuseholder (3 wires for 3 phase systems, 2 wires for single phase systems). Be sure to replace the main fuse safety cover after all connections are made and properly tightened.

5. **DO NOT SWITCH ON MAINS POWER AT THIS TIME.**

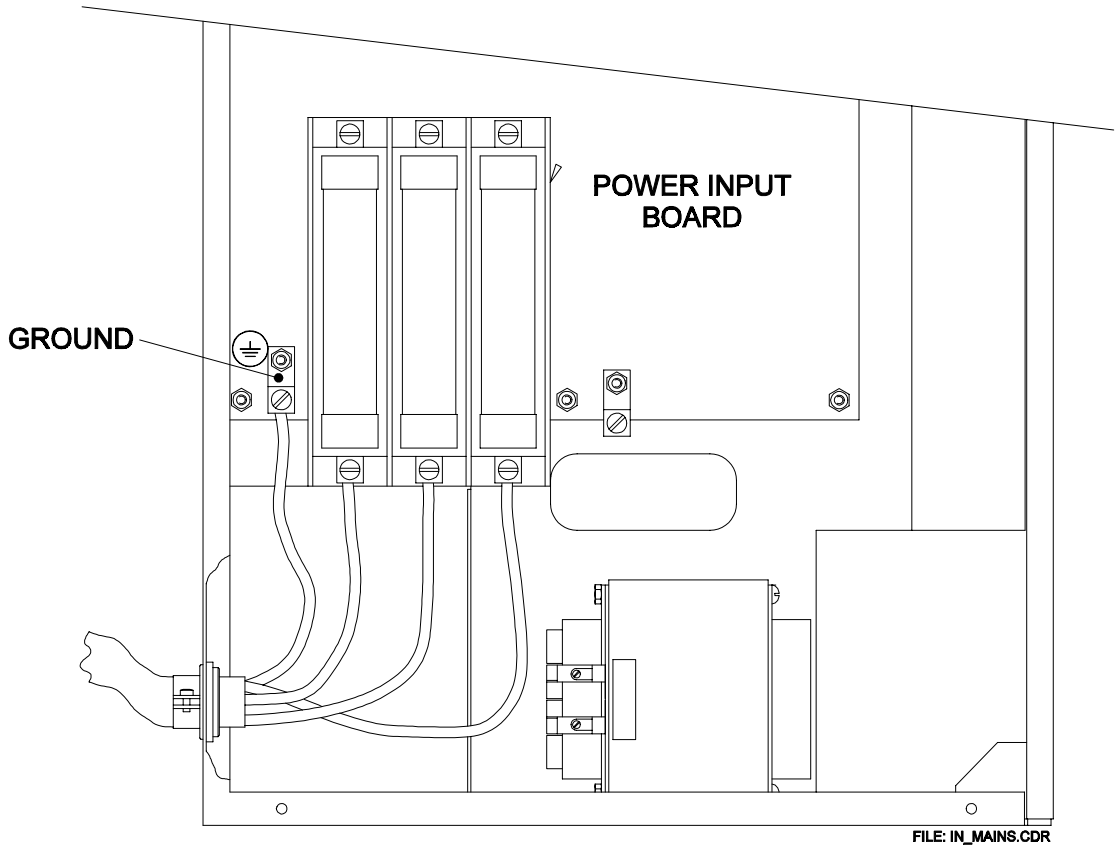

Figure 2-7: Generator mains connections

2.10.0 X-RAY TUBE HOUSING GROUND

A separate ground wire (10 AWG, 6mm^2) must be connected from each X-ray tube housing to one of the ground studs on the HT tank. Refer to figure 2-8 or 2-9. These ground locations may have other ground wires already connected, ensure that these existing ground wires are not disconnected when making the X-ray tube ground connection.
Failure to make this ground connection may result in intermittent operation and/or exposure errors.

2.11.0 HIGH TENSION CABLES

The X-ray tube(s) should be mounted on their normal fixtures i.e. tube stand, G.I. table or other devices.

1. Verify that the HT cable terminations are clean, in good condition i.e. no cracks, and coated with vapor proof compound.

2. Remove the plastic caps which cover the high voltage terminals on the HT tank. These should be saved in case of a future requirement to transport the generator or HT tank.

3. Connect the high tension cables as per the installation requirements. Use the right angle connectors for the HT transformer end. Ensure that the cables for tube 1 (and tube 2 if used) are plugged into the proper connectors on the HT tank. Refer to figure 2-8 and 2-9.

4. Be sure that the HT cable connectors are tight and there is ***no play between*** the connector insulator and the screw down ring.

2.11.0 HIGH TENSION CABLES (cont)

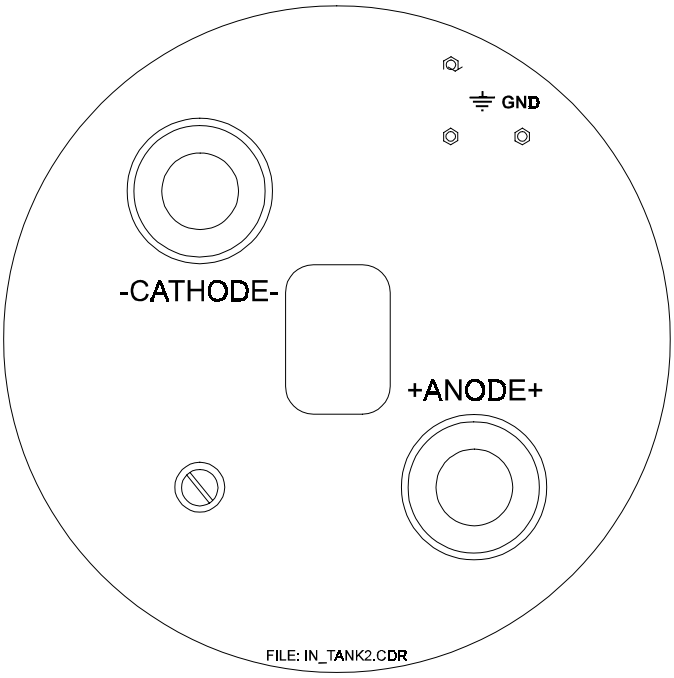

Figure 2-8: HV connectors (1 tube tanks)

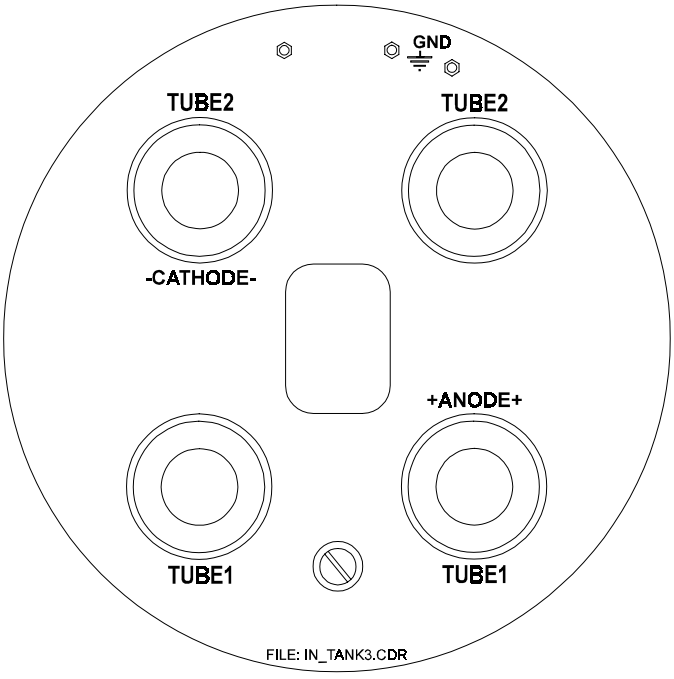

Figure 2-9: HV connectors (2 tube tanks)

2.12.0 PROGRAMMING THE LOW SPEED STARTER

This section applies only to units fitted with the low speed starter.

PLEASE BE SURE TO READ AND UNDERSTAND THIS SECTION FULLY BEFORE PROCEEDING.

The low speed starter boost and run voltages are fixed at nominally 240 VAC and 50 VAC respectively. The phase shift capacitor is fixed at 25 uF. Therefore, the low speed starter is capable of operating the "R" type stator tubes listed in table 2-1 only.

If the desired tube type is not listed, please contact CPI product support for assistance.

WARNING: ***240 VAC IS PRESENT ON THE LOW SPEED STARTER BOARD AT ALL TIMES THAT THE GENERATOR IS SWITCHED ON. TAKE APPROPRIATE PRECAUTIONS WHEN SERVICING THIS BOARD***

2.12.1 Low Speed Starter Tube Select Table

TABLE 2-1: TUBE TYPES (LOW SPEED STARTER)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)
Comet DO7 25/50 Ω stator	DX7
Comet DO9 25/50 Ω stator	DX9 0.6/2.0 DX9 1.2/2.0
Comet DO9 25/50 Ω stator	DX91HS DX92HS DX93HS
Comet DO10 25/50 Ω stator	DX10HS 0.6/1.0 DX10HS 1.0/2.0
Comet DX10 25/50 Ω stator	DX101HS DX104HS DX105HS
Comet XSTAR8 XSTAR74 25/50 Ω stator	XST-8 XST-74
Gilardoni Rotagil S/AS	AR11-30 AR30-60
Picker PX1300 3" anode Std "R stator"	PX1302 PX1312
Picker PX1400 4" anode Std "R" stator	PX1429 PX1431 PX1436 PX1482
Philips ROT350 ROT351	RO 17/50 SRO 22/50 SRO 33/100

2.12.1 Low Speed Starter Tube Select Table (Cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)
Toshiba Rotanode XH-121	E7132X
Varian B100 DX52 Std “R” stator	A102 A132 A142
Varian B100 “STD” stator	A102 A132 A142
Varian B130 B150 Std “R” stator	A192 A272 A282 A286 A292 G256 G292
Varian Diamond Std “R” stator	RAD13 RAD14 0.3/1.2 RAD14 0.6/1.2 RAD14 0.6/1.5
Varian Emerald Std “R” stator	RAD 8 RAD 68 RAD 74
Varian Saphire Std “R” stator	RAD21 RAD56 0.6/1.0 RAD56 0.6/1.2 RAD60 RAD92 RAD94
Varian DX62 300-400 kHu, “STD” stator	A192B A197 A256 A272 A282 A286 A292
Varian DX62U Universal 300-400 kHu, configured as “STD” or “R” stator	A192B A197 A256 A272 A282 A286 A292

2.13.0 PROGRAMMING THE DUAL SPEED STARTER

This section applies only to units fitted with the dual speed starter option.

The dual speed starter must be programmed for the X-ray tube type(s) used at this site. This is done via DIP switches SW1 and SW2 on the dual speed starter.

The following tube functions are set with these switches:

- High speed start and run voltages
- Low speed start and run voltages
- Brake time and brake voltage (high speed)
- Boost times
- Boost time increments. Boost time may be increased in 100 ms steps in the range of 100 to 700 ms

SW1 and SW2 on the dual speed starter must be set correctly to match the X-ray tube(s) in use. Failure to set these correctly may result in improper anode RPM and therefore may damage the X-ray tube.
PLEASE BE SURE TO READ AND UNDERSTAND THIS SECTION FULLY BEFORE PROCEEDING.

2.13.1 Setting tube type

1. Select the desired tube type from table 2-3. Record the tube type number (housing and insert) and the binary code as per the third column in the table. Please note that the tube compatibility applies only to the housing and inserts listed, i.e. for the specific manufacturer(s) shown.

2. If the desired tube type is not listed, please contact CPI product support for assistance.

3. The generator is factory configured to support one type of stator only (for example “R” type stator), therefore only stators of that type may be used with this generator. Refer to the customer product description form in chapter 1D of this manual for compatible X-ray tubes.
   REFER TO SECTION 2.13.2 IF IT IS DESIRED TO USE TUBES WITH STATOR TYPES NOT COMPATIBLE WITH THIS GENERATOR, OR IF YOU ARE NOT CERTAIN THAT THIS GENERATOR IS COMPATIBLE WITH THE STATOR IN YOUR TUBE.

4. Refer to figure 2-10. Set the DIP switch SW1 (for tube 1) with the binary code for the selected tube. The binary code shown in the table programs the tube type (housing and insert), for example housing type Varian Diamond with standard “R” stator and inserts per table 2-3 requires SW1-1 to be set OFF, SW1-2 OFF, SW1-3 ON, SW1-4 OFF and SW1-5 OFF. This programs the voltages, brake times, and boost times in table 2-3.
   Additionally, SW1-6 to SW1-8 may be set to give incremental increases in boost time over the preselected values (for example to run an older tube with worn bearings). For example, binary 000 gives zero increase, binary 001 gives 100 ms increase, binary 100 gives 400 ms increase, and binary 111 gives a 700 ms increase in boost time. SW1-6 represents bit 1, SW1-7 bit 2, and SW1-8 represents bit 3.

   EXAMPLE:
   Binary 100 = decimal 4 = 400 ms incremental boost time increase:

1	0	0
Bit 3	Bit 2	Bit 1
SW1-8	SW1-7	SW1-6

2.13.1 Setting tube type (cont)

5. The example DIP switch setting shown in figure 2-10 is for the example in step 4 with an incremental increase in boost time of 200 ms.

6. If this is a two-tube installation, repeat steps 1 to 4 using DIP switch SW2 for the second tube.

7. Please confirm all settings using a suitable tachometer to ensure proper anode RPM before making any exposures.

NOTE: ***FOR TUBES WHERE "LOW SPEED OPERATION ONLY" IS INDICATED, THE DUAL SPEED STARTER MUST BE PROGRAMMED FOR LOW SPEED ONLY, AND WHERE "HIGH SPEED OPERATION ONLY" IS INDICATED, THE DUAL SPEED STARTER MUST BE PROGRAMMED FOR HIGH SPEED OPERATION ONLY. REFER TO THE TUBE SELECTION SECTION IN CHAPTER 3C FOR THE PROCEDURE TO DO THIS.***

NOTE THAT THE EXAMPLE DIP SWITCH SHOWN IN FIGURE 2-10 IS REPRESENTATIVE OF ONE STYLE OF SWITCH ONLY. DEPENDING ON MANUFACTURER, YOUR DIP SWITCH STYLE MAY VARY. PLEASE NOTE THE ON/OFF POSITIONS CAREFULLY FOR YOUR UNIT.

2.13.1 Setting tube type (cont)

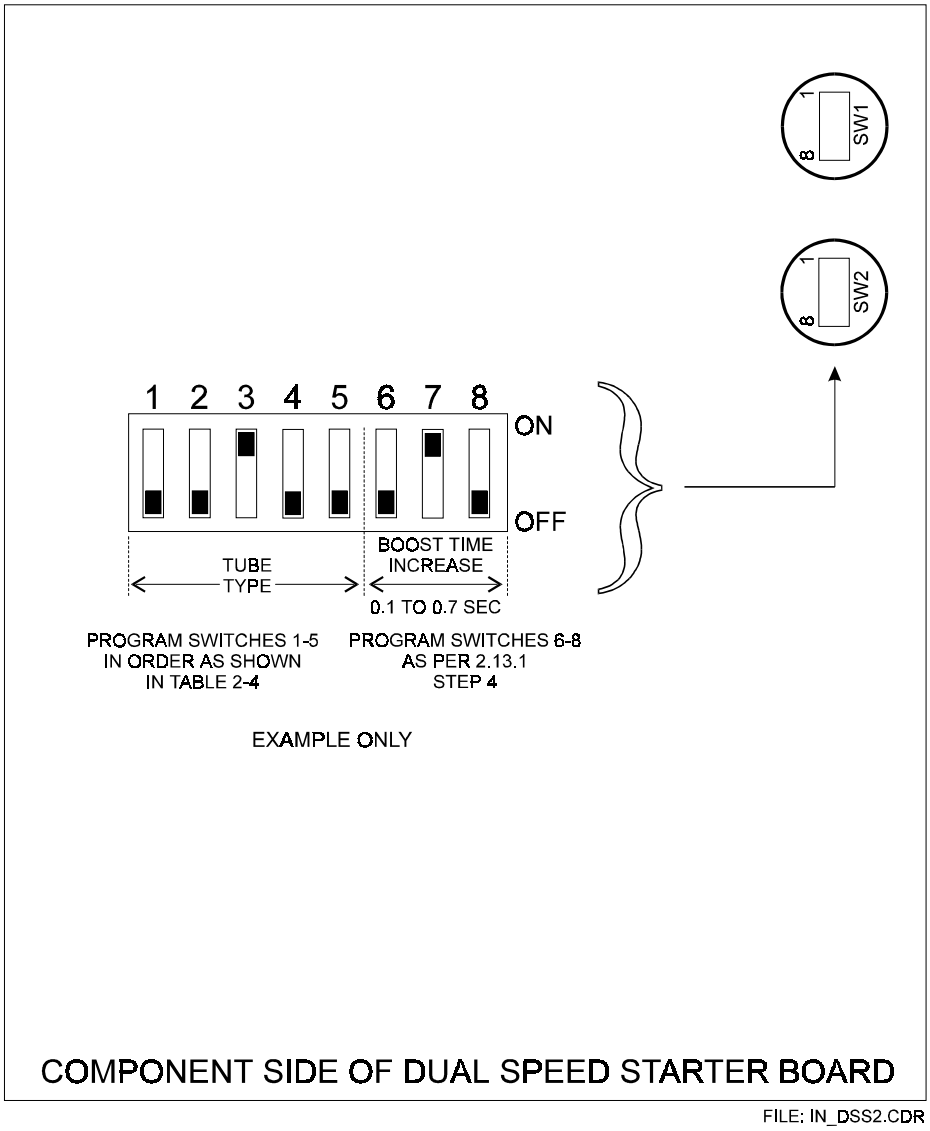

Figure 2-10: DIP switches on dual speed starter.

2.13.2 Confirming/Changing DSS Starter Type

The low speed and high speed phase shift capacitors for the stator start winding must be matched to the desired stator type, for example the required high speed phase shift capacitor is 6 uF for "R" type stators and 7.5 uF for GE Maxiray type stators. Therefore, for example, a dual speed starter configured for an "R" type stator CANNOT drive a GE Maxiray type stator.

Use the steps in this section to verify that the dual speed starter is compatible with the stator in the desired tube.

1. Record the part number of the dual speed starter assy in the subject generator. This is printed on a label near the top of the dual speed starter chassis.

2. Locate that part number in table 2-3, then note the value of the H.S. SHIFT CAPAC and the L.S. SHIFT CAPAC per the table. Those are the values of the phase shift capacitors in the dual speed starter. Only tubes requiring those capacitor values may be connected to the dual speed starter.

3. If it is desired to use a different tube from that shown in the compatible X-ray tubes section of the customer product description form, confirm that the desired tube (housing and insert) is listed in table 2-3 AND that the required dual speed starter part number for that tube per table 2-3 is the same as is fitted in your generator.

4. If the preceding steps confirm that the desired tube is fully compatible with the generator, you may proceed with setting the tube type as per section 2.13.1.

5. If in the preceding steps it is determined that the desired stator IS NOT compatible with the generator, the phase shift capacitors in the dual speed starter will need to be changed to match the requirements of the desired tube. Replacement capacitor kits are available to do this as noted in the next step.

6. Note the required H.S. SHIFT CAPAC and L.S. SHIFT CAPAC values, and the corresponding dual speed starter part number for the desired tube per table 2-3. Using those capacitor values, refer to table 2-2. From this table select the required conversion kit to convert to capacitors as required for the selected tube. The conversion kits are available through the factory/customer support.
   IF MAKING THE ABOVE CONVERSION, PLEASE BE SURE TO CHANGE THE PART NUMBER IDENTIFIED IN STEP 1 TO THE NEW CONFIGURATION USING AN INDELIBLE MARKER. THIS WILL ENSURE THAT CONFIGURATION CONTROL OF THE PRODUCT IS MAINTAINED

TABLE 2-2

HIGH SPD SHIFT CAPAC	LOW SPD SHIFT CAPAC	CONVERSION KIT P/N
6 uF	31uF	734424-00
7.5 uF	47 uF	734424-01
20 uF	60 uF	734424-02
5 uF	30 uF	734424-03
5 uF	45 uF	734424-04

NOTE: ***CAPACITOR VALUES SHOWN IN TABLES 2-3 AND 2-4 ARE EQUIVALENT VALUES OF THE PHASE SHIFT CAPACITORS IN THE DUAL SPEED STARTER. FOR EXAMPLE, THE STANDARD "R" VERSION OF THE DUAL SPEED STARTER USES TWO 12.5 uF CAPACITORS CONNECTED IN SERIES TO GIVE NOMINAL 6 uF FOR HIGH SPEED USE. THIS 6 uF CAPACITANCE IS CONNECTED IN PARALLEL WITH A 25 uF CAPACITOR TO GIVE 31 uF FOR LOW SPEED USE AS SHOWN IN THE TABLES.***

2.13.3 Dual Speed Starter Tube Select Table

All voltages in table 2-3 are at 60/180 Hz unless indicated otherwise.

TABLE 2-3: TUBE TYPES (HIGH SPEED STARTER)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	CODE Switches 1.....5	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Comet DO7 25/50 Ω stator	DX7	00000	**LOW SPEED OPERATION ONLY** (See note 1 at end of this table)				1.4 sec	240	50	6 uF	31 uF	733317-01
Comet DO9 25/50 Ω stator	DX9 0.6/2.0 DX9 1.2/2.0	00000	**LOW SPEED OPERATION ONLY** (See note 1 at end of this table)				1.4 sec	240	50	6 uF	31 uF	733317-01
Comet DO10 25/50 Ω stator	DI104 0.3/0.8 DI104 0.6/1.0 DI104 0.6/1.3 DI104 0.6/1.8	00011	420	80	150	3.0 sec	1.8 sec	240	80	6 uF	31 uF	733317-01
Comet DO10 25/50 Ω stator	DI106 0.3/0.8 DI106 0.6/1.0 DI106 0.6/1.3	10011	420	80	150	3.0 sec	2.2 sec	240	80	6 uF	31 uF	733317-01
Comet DO700WX 25/50 Ω stator	DI700 0.6/1.0 DI700 1.0/1.8	10011	420	80	150	3.0 sec	2.2 sec	240	80	6 uF	31 uF	733317-01
GE Maxiray 75 (3" anode) 23/23Ω equal Z stator	1.0/2.0 15° 0.6/1.0 11°	01110	400	90	80	2.0 sec	0.9 sec	230	70	7.5 uF	47 uF	733317-03
GE Maxiray 100 (4" anode) 23/23Ω equal Z stator	0.3/1.0 11° 0.6/1.0 11° 0.6/1.2 11° 0.6/1.5 11° 0.6/1.25 12.5° 1.0/2.0 15°	00101	400	90	80	3.0 sec	1.0 sec	230	70	7.5 uF	47 uF	733317-03
Gilardoni Rotagil	AR11-30 AR30-60	10101	**LOW SPEED OPERATION ONLY** (See note 1 at end of this table)				1.4 sec	220 *50 Hz*	60 *50 Hz*	6 uF	31 uF	733317-01

2.13.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	CODE Switches 1.....5	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Gilardoni Rotagil A/A5	AR20-50 AR30-100 AR40-100	01101	340 *150 Hz*	60 *150 Hz*	80	3.0 sec	1.4 sec	220 *50 Hz*	60 *50 Hz*	6 uF	31 uF	733317-01
Picker PX1300 3" anode Std "R stator"	PX1302 PX1312	11100	240	120	100	3.0 sec	2.3 sec	240	50	6 uF	31 uF	733317-01
Picker PX1400 4" anode Std "R" stator	PX1429 PX1431 PX1436 PX1482	01100	240	120	100	3.0 sec	4.5 sec	240	70	6 uF	31 uF	733317-01
Picker PX1400 4" anode "Q" stator	PX1429 PX1431 PX1436 PX1482	10110	340	60	100	3.0 sec	1.0 sec	240	70	20 uF	60 uF	733317-02 ***** 735925-02
Philips ROT350 ROT351	RO 17/50 SRO 22/50 SRO 33/100	00000	**LOW SPEED OPERATION ONLY** (See note 1 at end of this table)				1.4 sec	240	50	6 uF	31 uF	733317-01
Siemens Biangulix 8500 RPM (configured for 150 Hz operation)	BI 125/20/40	11101	400 *150 Hz*	90 *150 Hz*	80	3.0	1.9 sec	**HIGH SPEED OPERATION ONLY** (See note 1 at end of this table)		5 uF	N/A	733317-04
Siemens Opti-150 "S" stator	30/52R 20/40	00000	400	90	80	3.0	1.9 sec	240	50	5 uF	45 uF	733317-05
Siemens OptiTop 150/40/80HC-100L		01011	400	80	120	3.0 sec	1.0 sec	240	80	5 uF	30 uF	733317-06 ***** 735925-06
Siemens OptiTop 150/40/80HC-102L		01011	400	80	120	3.0 sec	1.0 sec	240	80	5 uF	30 uF	733317-06 ***** 735925-06

2.13.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	CODE Switches 1.....5	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Varian B100 DX52 Std “R” stator	A102 A132 A142	01000	400	100	100	3.0 sec	1.0 sec	240	60	6 uF	31 uF	733317-01
Varian B100 “P” stator	A102 A132 A142	01001	450	140	100	3.0 sec	0.8 sec	240	70	6 uF	31 uF	733317-01
Varian B100 “Q” stator	A102 A132 A142	11010	290	70	60	3.0 sec	0.8 sec	150	50	20 uF	60 uF	733317-02 * 735925-02
Varian B130 “P” stator	A192 A272 A282 A286 A292 G256 G292	11001	450	140	100	3.0 sec	1.3 sec	240	70	6 uF	31 uF	733317-01
Varian B130 B150 Std “R” stator	A192 A272 A282 A286 A292 G256 G292	00000	400	100	100	3.0 sec	1.4 sec	240	50	6 uF	31 uF	733317-01
Varian B130 B150 “Q” stator	A192 A272 A282 A286 A292 G256 G292	00110	290	70	60	3.0 sec	1.3 sec	150	50	20 uF	60 uF	733317-02 * 735925-02

2.13.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	CODE Switches 1.....5	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Varian Diamond Std "R" stator	RAD13 RAD14 0.3/1.2 RAD14 0.6/1.2 RAD14 0.6/1.5	00100	400	100	100	3.0 sec	1.2 sec	240	50	6 uF	31 uF	733317-01
Varian Emerald Std "R" stator	RAD 8 RAD 68 RAD 74	00000	**LOW SPEED OPERATION ONLY** (See note 1 at end of this table)				1.4 sec	240	50	6 uF	31 uF	733317-01
Varian Saphire Std "R" stator	RAD21 RAD56 0.6/1.0 RAD56 0.6/1.2 RAD60 RAD92 RAD94	10100	400	100	100	3.0 sec	2.3 sec	240	50	6 uF	31 uF	733317-01
Varian DX62 300-400 kHu, "STD" stator	A192B A197 A256 A272 A282 A286 A292	00000	400	100	100	3.0 sec	1.4 sec	240	50	6 uF	31 uF	733317-01
Varian DX62U Universal 300-400 kHu, configured as "STD" or "R" stator	A192B A197 A256 A272 A282 A286 A292	00000	400	100	100	3.0 sec	1.4 sec	240	50	6 uF	31 uF	733317-01

2.13.3 Dual Speed Starter Tube Select Table (cont)

THE DUAL SPEED STARTER USES MODULATION STRATEGIES TO OBTAIN THE DESIRED OUTPUTS. MEASURED VOLTAGES MAY NOT AGREE WITH THOSE LISTED IN THE TABLE. HOWEVER, THE CURRENTS FLOWING IN THE STATOR WINDINGS ARE EQUIVALENT TO THOSE THAT WOULD EXIST IF THE STATOR WAS EXCITED WITH THESE VOLTAGES.

NOTE 1: Tube types designated as low speed only or high speed only must be programmed for low speed only or high speed only operation. Refer to chapter 3, section 3C.5.1 for details.

***** Dual speed starter part numbers 733317-XX are used in 400 VAC 3ϕ generators and in 480 VAC 3ϕ generators with a line adjusting transformer. Dual speed starter part numbers 735925-XX are used in 230 VAC 1ϕ generators and in 480 VAC 3ϕ direct input generators (using no line adjusting transformer).

2.14.0 GENERATOR LOCKOUT SWITCH

A safety lockout switch (S3) is provided on the generator interface board. When this switch is in the **LOCKOUT** position, the generator cannot be switched on either from the console or from the adjacent service switch S2 on the generator interface board. This prevents inadvertent switching on of the generator while it is being serviced.

S3, the generator lockout switch, must be in the **NORMAL** position to enable switching the generator on. Refer to figure 2-11 for these switch locations.

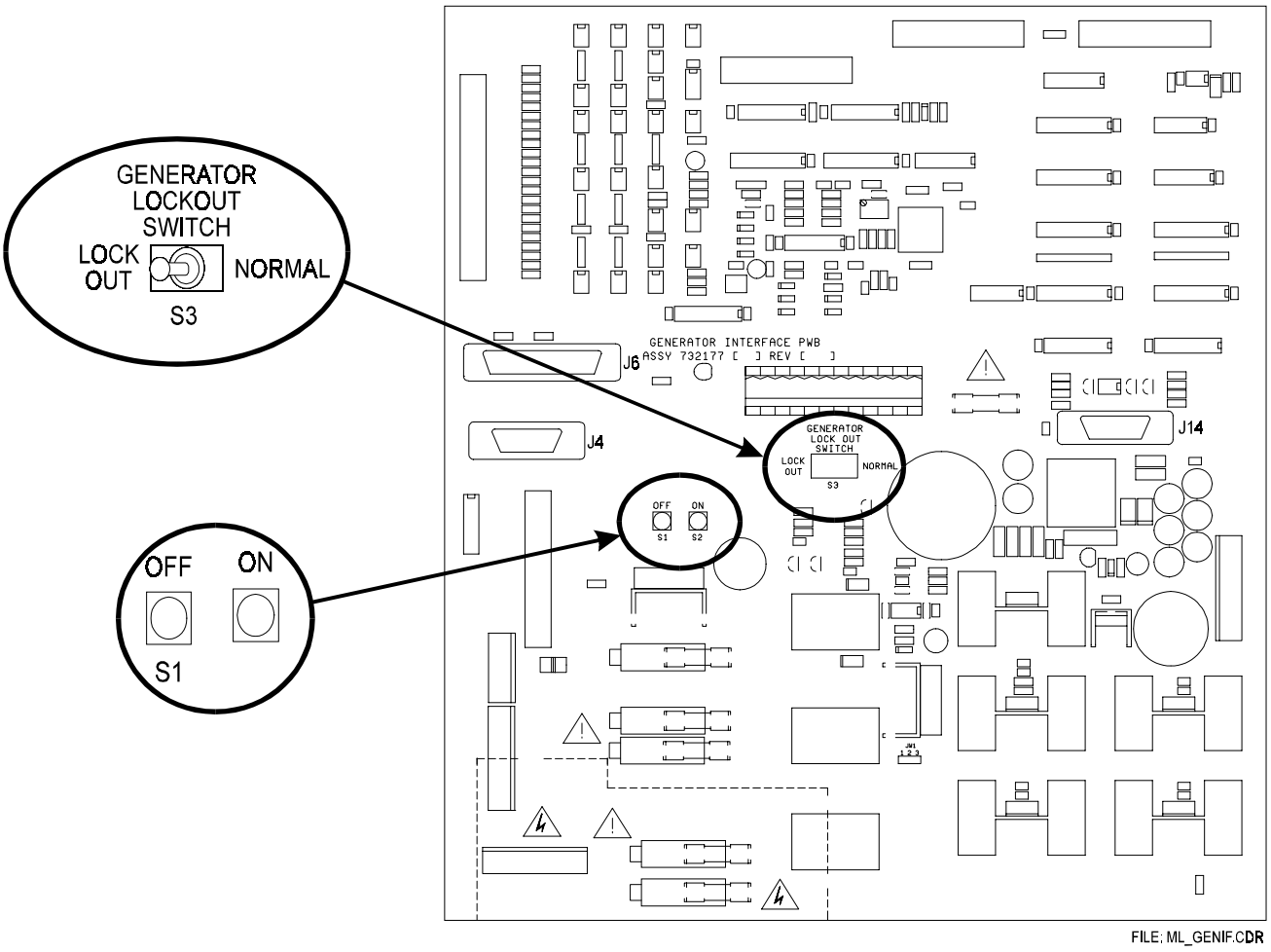

Figure 2-11: Location of lockout switch and local ON/OFF switches

2.15.0 SAFETY INTERLOCKS

It is strongly recommended that the following two interlocks be wired to the generator before preparing to make any exposures:

DOOR INTERLOCK
The room door interlock switch must be wired to TB4-4 and TB4-5 on the room Interface board. This switch will provide a closed contact when the door is closed.

X-RAY TUBE THERMAL SWITCH
The X-ray tube(s) thermal switch(s) should be connected to the generator for tube thermal protection. These may be connected either at the stator terminal blocks (section 2.9.4), or at the room interface board. The connections on the room interface board are TB4-8 and TB4-9 for tube 1, and TB4-6 and TB4-7 for tube 2.

2.16.0 CHECKING THE RAM BACKUP BATTERY VOLTAGE

It is recommended that the backup battery voltage be checked before continuing. The normal life expectancy of these batteries is estimated at 5 years.

CONSOLE CPU BOARD (23 X 56 cm consoles):

1. Turn the operator console upside down carefully to protect the front panel. Remove the 6 screws securing the base to the molded case.

2. Open the Console carefully such that the interconnecting cables are not strained.

3. Locate the battery on the console CPU board, refer to figure 2-12. Measure the battery voltage with a DVM. The top of the battery is the positive side; ground (TP2 on the board) is the negative side.

4. The nominal battery voltage should be approximately 3.0V, replace the battery if it is under 2.80V.

5. Before closing the console, refer to section 2.17.0, console CPU board DIP switch settings.

6. Re-assemble the console. DO NOT OVER TIGHTEN THE SCREWS SECURING THE BASE TO THE MOLDED CONSOLE TOP.

CONSOLE BOARD (31 X 42 cm consoles):

1. Disconnect all connections, including the console ground connection, from the rear of the operator console.

2. Turn the console upside down carefully to protect the front panel. Remove and temporarily set aside the jackscrews from the ‘D’ connectors on the rear of the console. Remove and temporarily set aside the hardware from the console ground stud.

3. Remove the 8 screws securing the base to the molded case.

4. Gently remove the console bottom (the metal bottom panel with the feet attached).

5. Locate the battery on the console board, refer to figure 2-12. Measure the battery voltage with a DVM. The top of the battery is the positive side; ground (TP2 on the board) is the negative side.

2.16.0 CHECKING THE RAM BACKUP BATTERY VOLTAGE (Cont)

6. The nominal battery voltage should be approximately 3.0V, replace the battery if it is under 2.80V.

7. Before closing the console, refer to section 2.17.0, console CPU board DIP switch settings.

8. Re-assemble the console in the reverse order of the above. Use of a removable thread locker (loctite or equivalent) is recommended when reinstalling the jackscrews to prevent them from loosening if the mating connectors are removed.
Reconnect the console ground and all cables removed in step 1.

GENERATOR CPU BOARD:

1. Locate the battery on the generator CPU board, refer to figure 2-12. Measure the battery voltage with a DVM. The top of the battery is the positive side, ground (TP21 on the board) is the negative side.

2. The nominal battery voltage should be approximately 3.0V, replace the battery if it is under 2.80V.

2.16.0 CHECKING THE RAM BACKUP BATTERY VOLTAGE (cont)

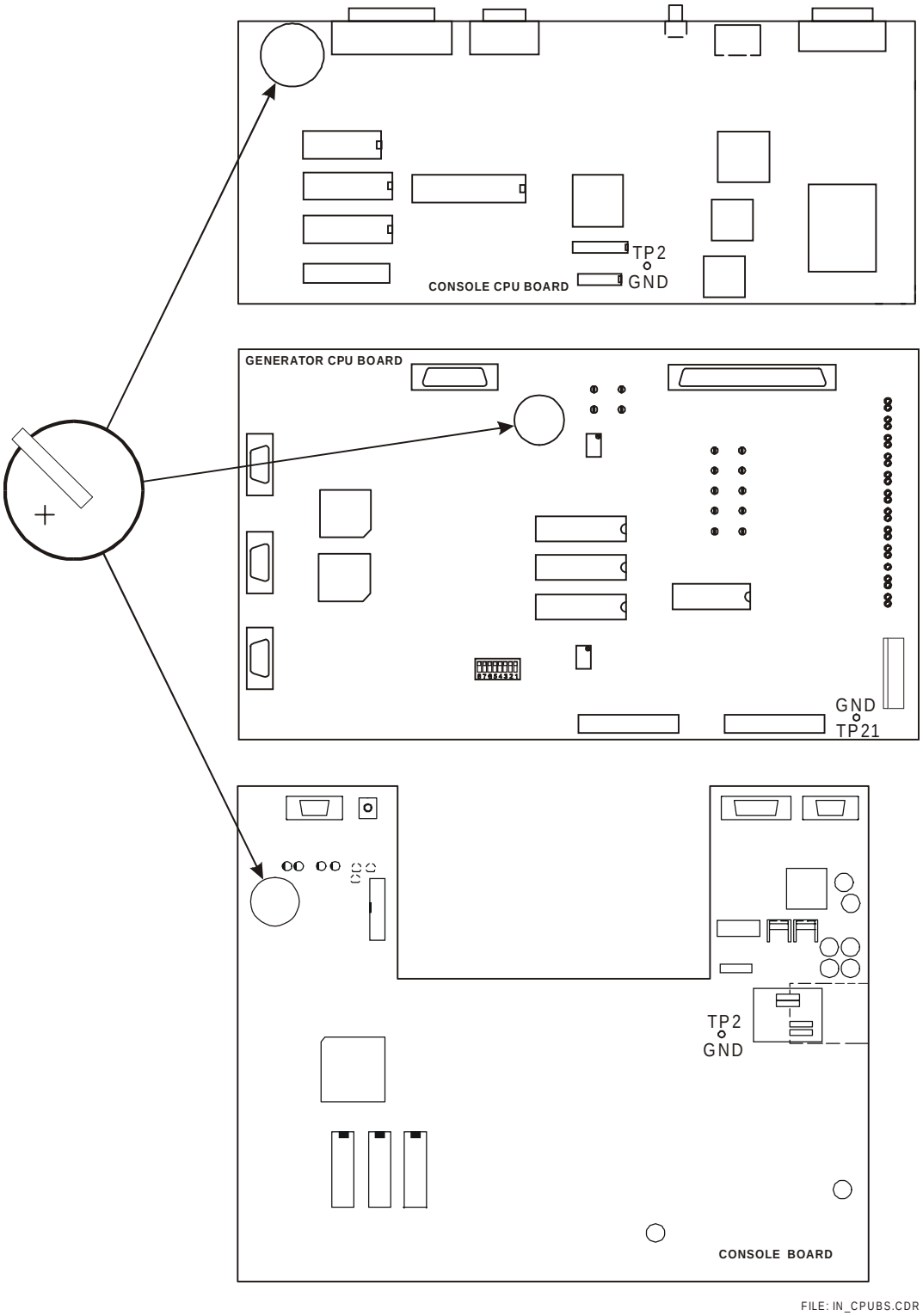

Figure 2-12: Location of batteries on generator and console CPU boards

2.17.0 DIP SWITCH SETTINGS

Before continuing, verify the DIP switch settings on the console CPU board and generator CPU board. These switches have been factory set but may have been readjusted, particularly if this generator is a re-install.

CONSOLE CPU BOARD (23 X 56 cm console) / CONSOLE BOARD (31 X 42 cm console)

- Verify the settings on SW1, the switches should all be set to OFF. Setting SW1-8 ON at power up restores factory default settings for the console. SW1-1 to SW1-7 should remain in the OFF position at all times.

GENERATOR CPU BOARD:

- Verify the settings on SW1. Refer to the table below for the proper settings for this switch.

GENERATOR POWER	MAXIMUM mA	SW1 -3	SW1-2	SW1-1
30 kW	320 mA	ON	ON	OFF
37.5 kW	400 mA	ON	OFF	ON
50 kW	630 mA	OFF	ON	ON
65 kW	800 mA	OFF	ON	OFF
80 kW	1000 mA	OFF	OFF	ON

SW1-4	OFF > 2 FILAMENT BOARDS	ON > I FILAMENT BOARD
SW1-5	OFF > 150 kV MAXIMUM	ON > 125 kV MAXIMUM
SW1-6	OFF > DUAL SPEED STARTER	ON > LOW SPEED STARTER
SW1-7	OFF > 2 TUBE GENERATOR	ON > 1 TUBE GENERATOR
SW1-8	OFF > SET FACTORY DEFAULTS	ON > DEFAULTS DISABLED

2.18.0 INITIAL RUN-UP

This section describes the procedure for initial power-on of the generator after it has first been installed.

2.18.1 Initial Voltage Measurements

1. Verify that the mains voltage and current capacity is correct for the generator installation. Refer to the product ID label on the generator cabinet and chapter 1C of this manual.

2. Temporarily remove the safety cover over the main input fuses in the generator.

3. If the mains supply is compatible with the generator, switch on the main breaker and/or disconnect switch and check for the following voltages:

NOTE: ***DO NOT SWITCH ON THE GENERATOR AT THIS TIME (ONLY THE AC MAINS TO THE GENERATOR IS TO BE SWITCHED ON AT THIS TIME).***

2.18.1 Initial Voltage Measurements (Cont)

WARNING: ***1. USE EXTREME CARE IN MEASURING THESE VOLTAGES. ACCIDENTAL CONTACT WITH MAINS VOLTAGES MAY CAUSE SERIOUS INJURY OR DEATH.***

2. MAINS VOLTAGE WILL BE PRESENT INSIDE THE GENERATOR CABINET, EVEN WITH THE CONSOLE SWITCHED OFF.

3. THE BUS CAPACITORS, LOCATED ON THE POWER INPUT BOARD OR ON THE BUS CAPACITOR ASSEMBLY (SINGLE PHASE UNITS ONLY), PRESENT A SAFETY HAZARD FOR A MINIMUM OF 5 MINUTES AFTER THE POWER HAS BEEN REMOVED FROM THE UNIT. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY PARTS.

PLEASE NOTE THAT THE VOLTAGE MEASURED IN STEP 4 WILL NOT NECESSARILY BE THE SAME AS THE VOLTAGE AT THE MAIN DISCONNECT BOX IN THE ROOM. THE REASON FOR THIS IS THAT A LINE ADJUSTING TRANSFORMER MAY BE USED WITH THE GENERATOR WHICH STEPS THE INCOMING LINE VOLTAGE TO THE GENERATOR UP OR DOWN.

GENERATORS WITH NO LINE ADJUSTING TRANSFOMER SHOULD HAVE THE SAME VOLTAGE IN STEP 4 AS IS SUPPLIED AT THE MAIN DISCONNECT BOX IN THE ROOM. UNITS WITH A LINE ADJUSTING TRANSFORMER SHOULD HAVE THE FOLLOWING VOLTAGES AT THE MAIN LINE FUSES IN THE POWER SUPPLY CABINET.

VOLTAGE AT MAIN DISCONNECT BOX (LINE ADJUSTING TRANSFORMER INPUT)	VOLTAGE AT MAIN FUSES IN POWER SUPPLY (LINE ADJUSTING TRANSFORMER OUTPUT)
480 VAC ± 10 %	400 VAC ± 10 %
400 VAC ± 10 %	480 VAC ± 10 %

4. Measure and record the voltage across the main line fuses in the power supply. Single phase units will only use one set of voltage measurements.

   L1 phase to L2 phase = _____ VAC.
   L1 phase to L3 phase = _____ VAC.
   L2 phase to L3 phase = _____ VAC.

5. Are these voltages within specification for the unit as per chapter 1C for generators without a line adjusting transformer, or within specification per the table above for units with a line adjusting transformer?

   ___ Check

6. Switch OFF the mains power to the generator. Verify that there is no voltage present across any of the mains input phases. Replace the safety cover on the main input fuse block, then switch ON the mains and generator.

7. Verify that the red LED (DS1) located near the center of the generator interface board is lit.

   _____ Check

8. Verify that the red LED (DC BUSS OK) located on the power input board is lit.

_____ Check

2.18.2 Initial Power Up

1. Switch on the generator at the console and observe the startup sequence on the console APR display.

   - MEMORY TEST.... will be displayed
   - HIGH FREQUENCY GENERATOR **XX** KW WILL BE DISPLAYED (**XX** will be the kW rating for that model)
   - The next screen will show console software revision and power software revision

2. In the generator control cabinet, verify the following:

   - On the generator CPU board verify that the following LEDs are ON (these indicate presence of the DC rails as indicated):

DS38	+5 V
DS41	+15 V
DS43	-15 V
DS45	+12 V
DS46	-12 V

3. In the power supply cabinet, verify the following:

   - On the auxiliary board verify that the following LEDs are ON:

CNTCTR CLSD
S.S. OK
+12V
-12V
+/- 35V

2.19.0 PROGRAMMING AND CALIBRATION USING THE CONSOLE

2.19.1 Entering Into Programming/Calibration Mode

This section presents a brief overview of the generator setup menu only. For more detail, refer to chapter 3C.

To enter into the programming and calibration mode for the generator follow the steps below. Refer to Figure 2-13 for references to APR buttons. This figure shows the APR button layout for the 23 X 56 (cm) Indico 100 console, and for the 31 X 42 (cm) console.

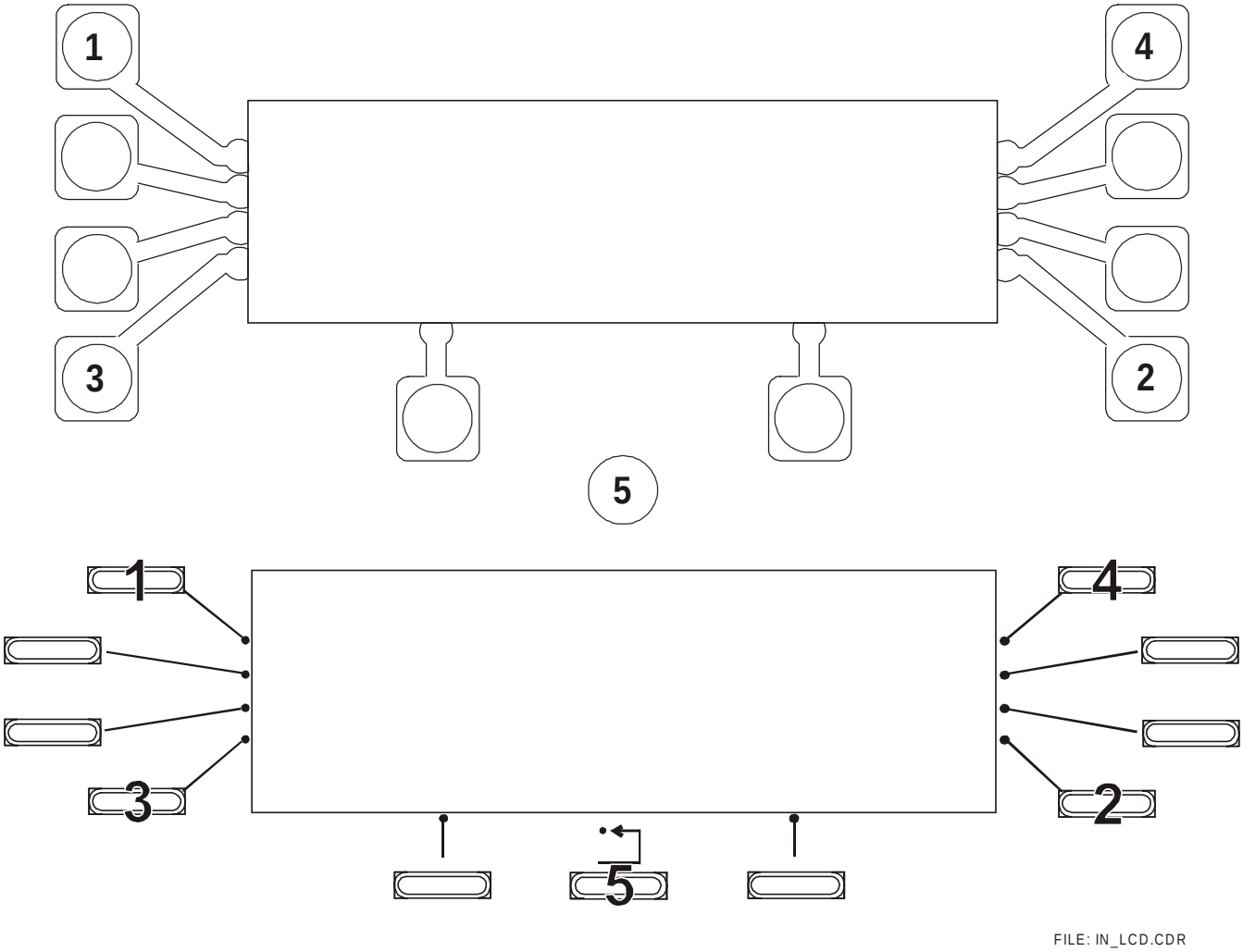

Figure 2-13: Programming/calibration mode reference

1. Start with the generator switched OFF.

2. While pressing and holding the RESET button [5], press the generator POWER ON button on the console

3. The generator will go through the start-up sequence, then display the message ENTER PASSWORD.

2.19.1 Entering Into Programming/Calibration Mode (Cont)

4. Enter the factory default password by pressing the following button sequence: [1] - [2] - [3] - [4].

5. The APR menu will now display the following:

```
                * GENERATOR SETUP *
UTILITY                    APR EDITOR: DISABLED
                             GEN  CONFIGURATION
                                        DATA LINK
EXIT SETUP
```

2.19.2 Menu Selections

UTILITY
Allows access to the following functions:

SET TIME & DATE:
Allows setting of: YEAR, MONTH, DAY, HOUR, and MINUTE

ERROR LOG:
Allows review of the generators error log for recorded errors.

STATISTICS:
Allows review of the tube exposure counter(s), the fluoro exposure counter if applicable, and the generator accumulated exposure counter. Also allows resetting of the tube exposure counter(s), and the fluoro exposure counter if used.

CONSOLE:
Allows setting the following parameters for the installation: key speed (scroll rate for the displays), speaker volume, LCD screen mode, and APR mode.

APR EDITOR

This enables or disables technique factor changes. When **APR EDITOR** is set to **ENABLED**, the technique factors may be changed. The new values may then be saved to overwrite the existing values. Reference chapter 3C for further information.

2.19.2 Menu Selections (Cont)

GEN CONFIGURATION

Allows the service engineer to access the following functions. Further details are in chapter 3C.

- TUBE SELECTION — Selects from the available group of X-ray tubes.
- GENERATOR LIMITS — Sets the operating limits of the generator.
- RECEPTOR SETUP — Allows programming of each image receptor.
- I/O CONFIGURATION — Allows setting the inputs and outputs of all image receptors.
- AEC SETUP — Defines properties for each channel of the AEC device.
- AEC CALIBRATION — Allows calibration of the AEC device.
- FLUORO SETUP — Allows setting of the fluoro properties.
- TUBE CALIBRATION — Enables the X-ray tube auto calibration feature.

DATA LINK

Used with the CPI GenWare™ utility software. This allows for data communication with a computer in order to download additional tube types, transfer APR data, run the A^2EC^2 ™ utility, and for other minor functions. Further documentation is included with the software package in the form of an MS WORD document (MANUAL.DOC).

A computer (i.e. laptop) and a 9 pin null modem cable with socket connectors (female) on both ends are required to run this software and interface to the generator.

2.20.0 TUBE AUTO CALIBRATION

Prior to beginning tube auto calibration, the tube(s) used in this installation must be properly selected, and the generator limits should be programmed. Refer to chapter 3C.

It is recommended that the tube(s) be conditioned (seasoned) before beginning tube auto calibration, refer to chapter 6.

WARNING: ***THE FOLLOWING PROCEDURES PRODUCE X-RAYS. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

CAUTION: ***ALWAYS VERIFY THE MANUFACTURER OF THE TUBE INSERT. IF THE X-RAY TUBE HAS BEEN REBUILT, THE TUBE INSERT AND TUBE HOUSING MAY BE FROM DIFFERENT MANUFACTURERS.***

Step	Action	Result
1.	From the **GENERATOR SETUP** menu (section 2.19.1) select **GEN CONFIGURATION**.	The **TUBE CALIBRATION** menu will display.
2.	Select **TUBE CALIBRATION**.	The **TUBE AUTO-CAL** menu appears.
3.	Select the desired tube (tube 1 or tube 2) by pressing the **TUBE** button.	The selected tube will appear. Selection of the second tube is only available on two tube generators.
4.	Press **FOCAL SPOT** to toggle between **SMALL** and **LARGE.** Start with **SMALL**.	The selected focal spot displays.
5.	Press and hold the X-RAY button (or use the optional handswitch) to begin the calibration procedure.	The menu will indicate the mA and filament current while the generator takes a series of exposures.
6.	Press **RETURN** to repeat calibration on the other focal spot or on the other tube.	
7.	When auto-calibration is completed, press **EXIT** to exit the tube auto calibration menu.	The **GEN CONFIGURATION** menu will display.
8.	Press **EXIT** to return to the **GENERATOR SETUP** menu.	The **GENERATOR SETUP** menu will display.
9.	Press **EXIT SETUP** to exit out of the setup and calibration mode and return to the normal operation mode.	

NOTE: ***SHOULD AN ERROR OCCUR DURING AUTO CALIBRATION, AN ERROR MESSAGE WILL BE DISPLAYED. THE GENERATOR WILL THEN LIMIT THE TUBES OPERATION TO THE RANGE IN WHICH IT WAS CALIBRATED, THUS ALLOWING FOR PARTIAL OPERATION OF THE GENERATOR.***

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CHAPTER 3

SYSTEM INTERFACING, PROGRAMMING, AND AEC/ABS CALIBRATION

3.0.0 INTRODUCTION

3.1.0 Purpose

This chapter describes the interfacing to the generator of the X-ray room imaging equipment, and programming of the Millenia and Indico 100 family ofgenerators. This section allows the installer to record the necessary information to complete the installation as well as to record the programming values. The installation of the AEC (Automatic Exposure Control) and ABS (Automatic Brightness Stabilization) devices and their calibration are also covered in this chapter.

This Chapter contains the following sections.

Section	Title
3A	Setup information.
3B	System interfacing
3C	Programming the generator
3D	Automatic Exposure Control (AEC) calibration
3E	Automatic Brightness Stabilization (ABS) calibration

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CHAPTER 3

SECTION 3A

SETUP INFORMATION

CONTENTS:

3A.1.0 INTRODUCTION

Please record the setup information for your installation in this section before programming the generator. Enter the information appropriate for your generator model. The data tables will accommodate installations up to a standard R&F installation with the following: tilting G.I. table with bucky, spot film device, standard image tube with a medical T.V. system, wall bucky and an overhead tube stand, spot film camera and a digital acquisition system.

3A.2.0 INSTALLATION RECORD

3A.2.1 X-Ray Tubes

Please enter the appropriate information.

a)	Over table X-ray tube (or TUBE # 1)		
b)	Manufacturer and type:		
c)	Focal spot combination:	large =	small =
d)	kW of each focal spot:	large =	small =
e)	Maximum kVp:		
f)	Type of stator:		
g)	Dual or single speed:		
h)	Stator delay:	sec =	
i)	Start and run voltage, low speed:	start volts =	run volts =
j)	Start and run voltage, high speed:	start volts =	run volts =
k)	Brake voltage:	volts =	
l)	Maximum filament current:	amps =	
m)	Minimum filament current, stand-by:	amps =	
n)	Thermal switch included:		
o)	Under table X-ray tube (or TUBE # 2)		
p)	Manufacturer and type:		
q)	Focal spot combination:	large =	small =
r)	kW of each focal spot:	large =	small =
s)	Maximum kVp:		
t)	Type of stator:		
u)	Dual or single speed:		
v)	Stator delay:	sec =	
w)	Start and run voltage, low speed:	start volts =	run volts =
x)	Start and run voltage, high speed:	start volts =	run volts =
y)	Brake voltage:	volts =	
z)	Maximum filament current:	amps =	
aa)	Minimum filament current, stand-by:	amps =	
bb)	Thermal switch included:		
cc)	X-ray tube fan included:		

3A.2.2 Mains Supply And Fusing

Please record the following information on the mains voltage and current capacity. Check that the information is appropriate for the generator according to the nameplate on the generator cabinet.

Line voltage: _____ VAC

Line frequency: __ 50 Hz. __ 60 Hz. Line capacity: _____ kVa

Disconnect fuses (main): _____ amps

3A.2.3 Automatic Exposure Control

Chamber Type (optional):

Solid State: _____ Ion Chamber _____ PMT _____

Make: _____ Model: _____

Receptors with AEC (optional):

Table bucky	__ yes	Spot film device	__ yes	Digital System	__ yes
Wall bucky	__ yes	Auxiliary bucky	__ yes		

3A.2.4 Collimator

Type:	_____
Compatible with X-ray tube:	__ yes __ no
Exposure interlock (dry contacts):	__ yes __ no
Tomo/stereo by-pass:	__ yes __ no

3A.2.5 Image System

Conventional: _____ (make and model)
Digital: _____(make and model)

Image intensifier:	___dual mode	___tri-mode
24 hour supply:	__ yes	__ no__
Image system park/position switch.	__ yes	__ no
Fluoro foot switch to initiate fluoro and spot exposure:	__ yes	__ no_
Spot film advance delay: greater than 850 mSec. __ yes		__ no
Remote Fluoro controller.	__ yes	__ no
AEC compensation for multi-spot SFD use.	__ yes	__ no

3A.2.6 ABS Pickup Assembly

Optical diode: _____ PMT: _____ Proportional DC: _____ Composite Video _____

Make: _____ Model: _____

3A.2.7 Table Type

Table type: _____ Model/Make: _____

Grid: _____ Ratio: _____ L/P Inch: _____ Focus Distance: _____

3A.2.8 Wall Receptor

Type: _____

Grid: _____ Ratio: _____ L/P Inch: _____ Focus Distance: _____

3A.2.9 Receptor Assignment

Receptor 1: _____

Receptor 2: _____

Receptor 3: _____

Receptor 4: _____

Receptor 5: _____

Receptor 6: _____

3A.3.0 X-RAY TUBE AND GENERATOR PARAMETER WORKSHEET

Note: The information in this table is to be derived from the GEN CONFIGURATION menu.

Generator Model: _____ Serial No: _____

TUBE SELECTION	TUBE 1		TUBE 2	
	DEFAULT	SELECTED	DEFAULT	SELECTED
TUBE SELECTED				
TUBE SPEED				
MAX SF KW LS				
MAX LF KW LS				
MAX SF KW HS				
MAX LF KW HS				
MAX KV				
MAX SF MA				
ANODE HU WARNING				
ANODE HU LIMIT				
SF STANDBY				
LF STANDBY				
SF MAX				
LF MAX				
FIL BOOST				
FIL PREHEAT				
GENERATOR LIMITS	DEFAULT	SELECTED		
MAX KW				
MAX MA				
MIN MA				
MAX MAS				

3A.4.0 IMAGE RECEPTOR PROGRAMMING WORKSHEET

IMAGE RECEPTOR PROGRAMMING WORKSHEET DATE:_____ SERIAL #:_____

FUNCTION	RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4	RECEPTOR 5	RECEPTOR 6
NAME						
TUBE						
TOMO						
FLUORO						
SERIAL						
AEC CHANNEL						
INTERFACE OPTS						
RECEPTOR SYM						
FLUORO HANG						
RAD HANG						
LAST IMAGE HOLD						
MEMORY						
REM TOMO BUT						
SF/LF SWITCH						
AEC BACKUP						
AEC BACKUP MAS						
AEC BACKUP MS						

3A.5.0 I/O CONFIGURATION WORKSHEET

NOTE: BOXES WITH DOTTED LINES CANNOT HAVE THEIR STATE CHANGED!

FUNCTIONS	STANDBY	PREP	GEN RDY	RAD EXP	FLUORO EXP
INPUTS					
REMOTE EXP	-----		-----		-----
REMOTE PREP	-----		-----	-----	-----
REMOTE FL. EXP	-----	-----	-----	-----	
CONSOLE EXP	-----		-----		-----
CONSOLE PREP	-----		-----	-----	-----
TOMO EXP	-----	-----	-----		-----
REM. TOMO SEL		-----	-----	-----	-----
I/I SAFETY	-----		-----		
COLL. ITLK	-----		-----		
BUCKY CONTACTS	-----	-----	-----		-----
SPARE			-----		
THERMAL SW 1			-----		
THERMAL SW 2			-----		
DOOR ITLK			-----		
MULTI SPOT EXP		-----	-----	-----	-----
OUTPUTS					
BKY 1 SELECT					
BKY 2 SELECT					
BKY 3 SELECT					
TOMO/BKY 4 SEL					
TOMO/BKY STRT					
ALE					
COLL. BYPASS					
ROOM LIGHT					
SPARE					

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CHAPTER 3

SECTION 3B

SYSTEM INTERFACING

CONTENTS:

3B.1.0 INTRODUCTION

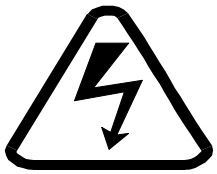
The Indico 100 generator may be interfaced to various tables, imaging systems, tube stands, tomographic devices, AEC pickups, Buckys, ABS pickups, X-ray tubes and collimators.

The generator interface may be programmed to supply a voltage, an isolated contact, receive a voltage, or an external isolated contact.

All interfacing cables enter the generator at the rear of the generator cabinet.

NOTE: ***The installer must provide the necessary interfacing cables.***

WARNING



NOTE: ***The generator interface board has 110 and 220 VAC present at all times that the main disconnect is switched ON. Use caution when servicing this board.***

3B.2.0 LOCATIONS OF INPUTS AND OUTPUTS

3B.2.1 Generator Pictorial Showing Connections

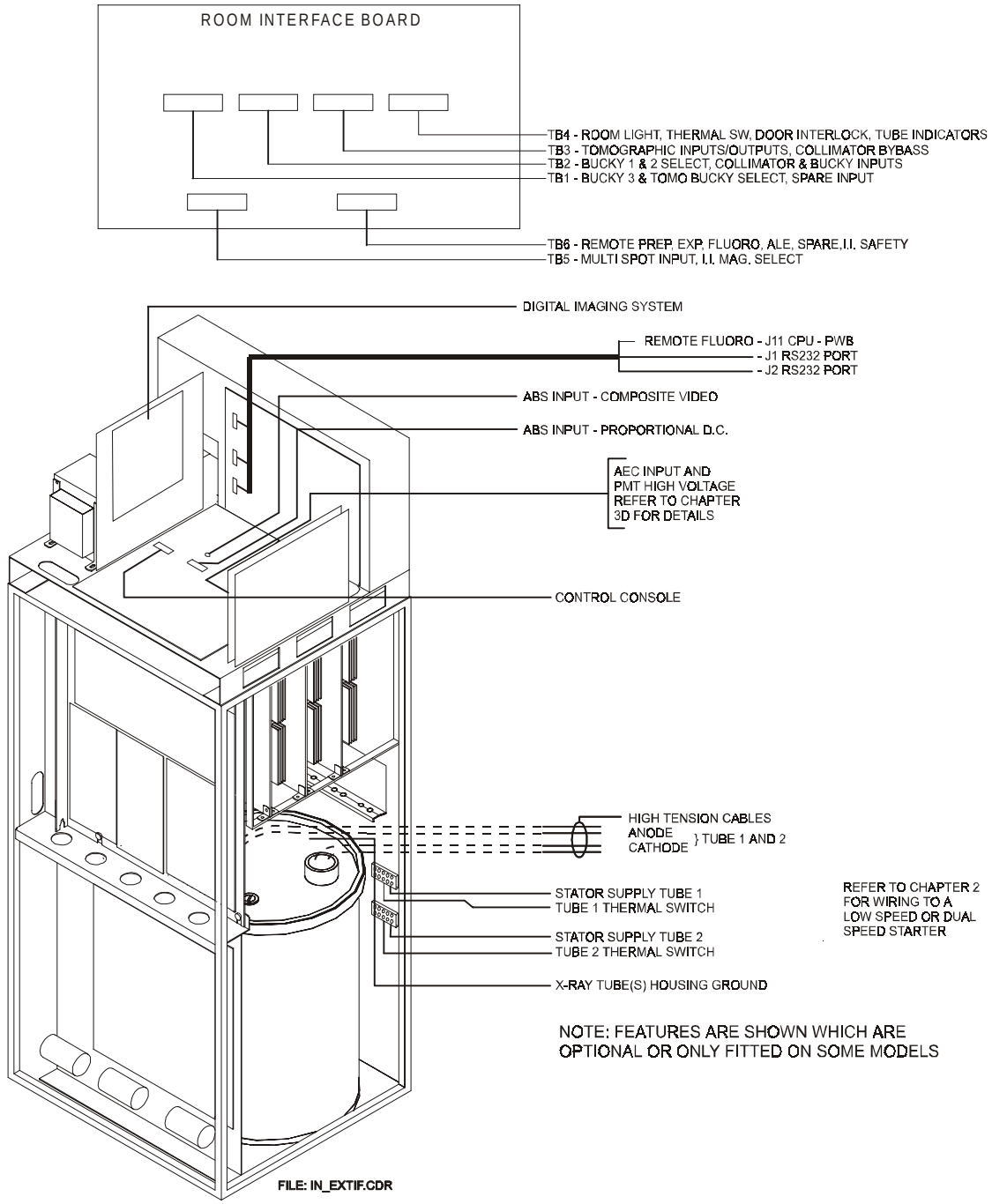


Figure 3B-1: Generator to room interface

CAUTION: ***ENSURE THAT ALL X-RAY TUBE HOUSINGS ARE CONNECTED TO THE GROUND STUD ON THE HT TANK. USE A SEPARATE GROUND WIRE FOR EACH TUBE, #10 AWG (6 mm^2) OR GREATER.***

3B.2.2 Low Speed/Dual Speed Starter

Refer to chapter 2 (installation) for instructions on wiring to the low speed or dual speed starter terminal blocks. Note that the X-ray tube thermal switches may be connected at the starter terminal blocks, or at the room interface board. Both sets of terminals are connected in parallel, and either may be used.

3B.2.3 High Tension Transformer

Accepts the high tension cables from either one or two x-ray tubes.

3B.2.4 Generator Interface Board

The generator interface board accepts the following (ABS only on R&F generators):

- ABS - composite video (J8).
- ABS - proportional DC (J7).

(Jumpers must be configured for different ABS types, refer to chapter 3E).

- Control console (J4).

3B.2.5 Generator CPU Board

The generator CPU board accepts the following (all are optional):

- Remote fluoro controller (J11).
- RS 232 Port (J1).
- RS 232 Port (J2).

3B.2.6 AEC Board

Depending on the Indico 100 generator's configuration, different AEC boards may be fitted. Refer to chapter 3D:

3B.2.7 Console CPU Board

The optional hand switch connects to the console CPU board, refer to chapter 2 for details. If it is desired to connect a remote fluoro footswitch (normally customer supplied), connect to TB6 pins 5 & 6 on the room interface board, or optionally to terminals "F" and "COM" on TB1 on the console CPU board (23 X 56 cm consoles), or to pins 7 & 9 of J13 on the 31 X 42 cm console. Refer to chapter 2.

3B.2.8 I/0 Expansion Board (optional)

This optional I/0 board will be used when the Indico 100 generator is interfaced with digital systems, film changers and various dedicated products. A separate supplement will be included in the manual for this board, if fitted.

3B.2.9 Room Interface Board

All the necessary inputs and outputs for the external room equipment are located on this board.

- TB1 - Bucky 3 and tomo bucky select, spare input,
- TB2 - Bucky 1 and 2 select, collimator and bucky inputs.
- TB3 - Tomographic inputs and outputs, collimator bypass.
- TB4 - Room light, thermal switches, door interlock, tube indicators.
- TB5 - Multiple spot input, I.I. mag. select.
- TB6 - Remote prep, exposure and fluoro inputs, I.I. safety input, ALE output, spare output.

3B.3.0 FEATURES OF THE ROOM INTERFACE BOARD

Refer to the following schematics and figures.

- Figure 3B-2, room interface board layout.
- Generator interface board schematic, drawing 732175 (sheet 1).
- Room interface board schematic, drawing 733182.

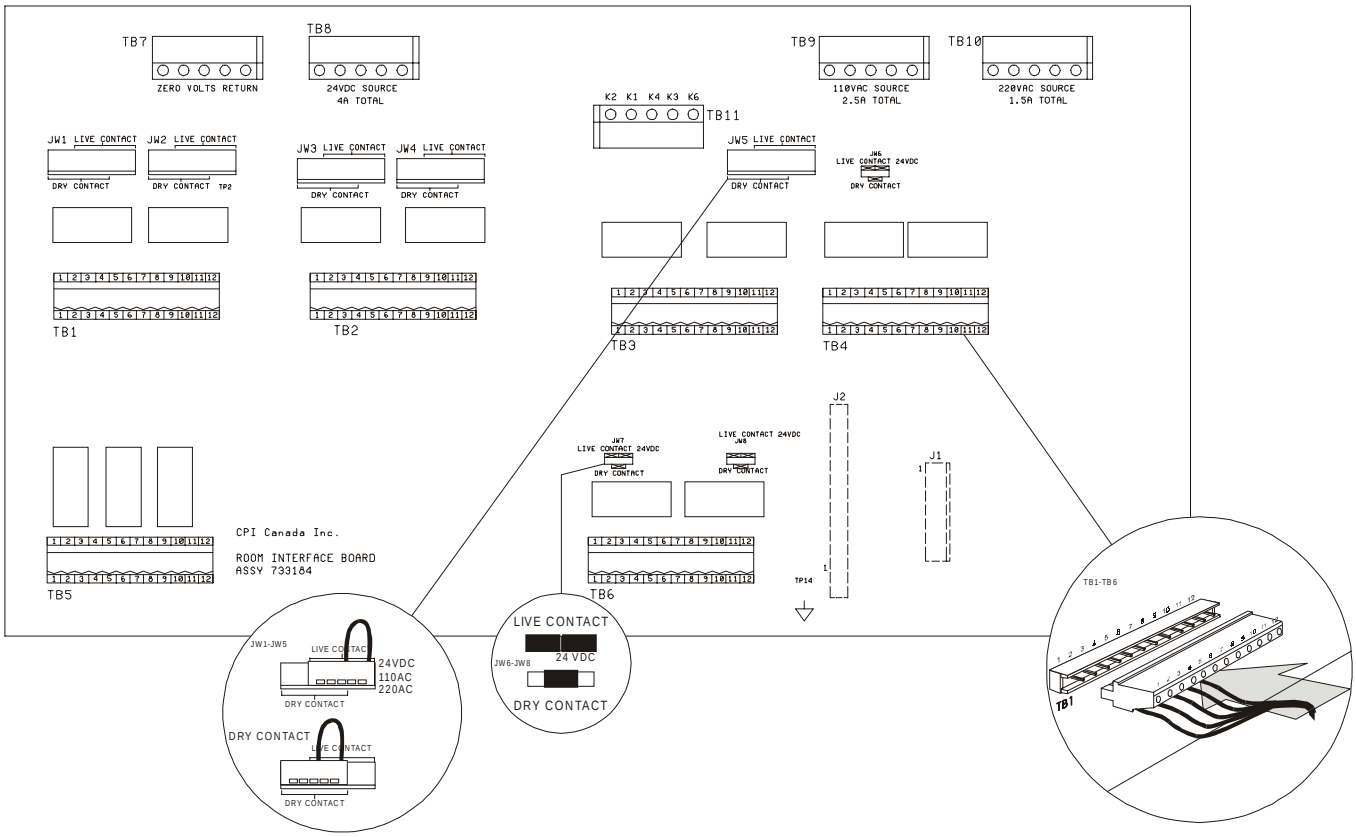


Figure 3B-2: Room interface board

3B.3.1 Inputs

- All inputs are opto coupled, select inputs may be configured to use an external +/- 24 VDC source or may be configured to accept a closed dry contact.
- Note the following inputs and jumper configurations per the table below:

NOTE: ***The Indico 100 generator is shipped from the factory with all inputs configured for dry contact inputs.***

JUMPER CONFIGURATION (INPUTS):

ROOM INTERFACE BOARD	GENERATOR INTERFACE BOARD JUMPER CONFIGURATION
TB1 PINS 4 & 5 (SPARE)	JW7 PINS 1-2, 3-4 = DRY CONTACT INPUT JW7 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB2 PINS 6 & 7 (COLLIMATOR)	JW9 PINS 1-2, 3-4 = DRY CONTACT INPUT JW9 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB2 PINS 4 & 5 (BUCKY CONTACTS)	JW10.PINS 1-2, 3-4 = DRY CONTACT INPUT JW10 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB3 PINS 6 & 7 (TOMO EXPOSURE)	JW3 PINS 1-2, 3-4 = DRY CONTACT INPUT JW3 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB3 PINS 4 & 5 (REMOTE TOMO SELECT)	JW2 PINS 1-2, 3-4 = DRY CONTACT INPUT JW2 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB4 PINS 8 & 9 (THERMAL SWITCH 1)	DRY CONTACT INPUT ONLY
TB4 PINS 6 & 7 (THERMAL SWITCH 2)	DRY CONTACT INPUT ONLY
TB4 PINS 4 & 5 (ROOM DOOR INTLK)	DRY CONTACT INPUT ONLY
TB5 PINS 11 & 12 (MULT. SPOT EXPOSURE)	JW6 PINS 1-2, 3-4 = DRY CONTACT INPUT JW6 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 9 & 10 (REMOTE EXPOSURE)	JW15 PINS 1-2, 3-4 = DRY CONTACT INPUT JW15 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 7 & 8 (REMOTE PREP)	JW14 PINS 1-2, 3-4 = DRY CONTACT INPUT JW14 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 3 & 4 (I.I. SAFETY)	JW8 PINS 1-2, 3-4 = DRY CONTACT INPUT JW8 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 5 & 6 (REMOTE FLUORO EXP)	DRY CONTACT INPUT ONLY

3B.3.2 Outputs

- Outputs are via relay contacts, some of which may be configured to supply a dry contact closure or to supply 24 VDC, 110 VAC, or 220 VAC upon closure.
- Note the following outputs and jumper configurations per the table below:
- To supply power to a ***grounded*** load, use TB1 pin 12 (for example) and jumper on "dry contacts". This applies also to TB1 pin 1, TB2 pin 12, TB2 pin 1 and TB3 pin 12.

NOTE: ***The Indico 100 generator is shipped from the factory with JW1 to JW5 configured for dry contacts, and JW6 to JW8 configured for 24 VDC output on relay closure.***

JUMPER CONFIGURATION (OUTPUTS):

ROOM INTERFACE BOARD	ROOM INTERFACE BOARD JUMPER CONFIGURATION
TB1 PINS 11 & 12 (BUCKY 3 SELECT)	JW2 DRY CONTACTS OUTPUT JW2 LIVE CONTACTS OUTPUT
TB1 PINS 1 & 2 (TOMO BUCKY SELECT)	JW1 DRY CONTACTS OUTPUT JW1 LIVE CONTACTS OUTPUT
TB2 PINS 11 & 12 (BUCKY 1 SELECT)	JW4 DRY CONTACTS OUTPUT JW4 LIVE CONTACTS OUTPUT
TB2 PINS 1 & 2 (BUCKY 2 SELECT)	JW3 DRY CONTACTS OUTPUT JW3 LIVE CONTACTS OUTPUT
TB3 PINS 11 & 12 (TOMO/BUCKY START)	JW5 DRY CONTACTS OUTPUT JW5 LIVE CONTACTS OUTPUT
TB3 PINS 1 & 2 (COLLIMATOR BYPASS)	DRY CONTACT OUTPUT ONLY
TB4 PINS 11 & 12 (ROOM LIGHT)	DRY CONTACT OUTPUT ONLY
TB4 PINS 1 & 2 TUBE 2 INDICATOR TB4 PINS 1 & 3 TUBE 1 INDICATOR	JW6 PINS 1-2, 3-4 = 24VDC OUTPUT JW6 PINS 2-3 = DRY CONTACT OUTPUT
TB5 PINS 8 & 9 (I.I. MAG 1)	DRY CONTACT OUTPUT ONLY
TB5 PINS 5 & 6 (I.I. MAG 2)	DRY CONTACT OUTPUT ONLY
TB5 PINS 2 & 3 (I.I. MAG 3)	DRY CONTACT OUTPUT ONLY
TB6 PINS 1 & 2 (ALE OUTPUT)	JW7 PINS 1-2, 3-4 = 24VDC OUTPUT JW7 PINS 2-3 = DRY CONTACT OUTPUT
TB6 PINS 11 & 12 (SPARE OUTPUT)	JW8 PINS 1-2, 3-4 = 24VDC OUTPUT JW8 PINS 2-3 = DRY CONTACT OUTPUT

3B.3.3 Selecting Output Voltages

Five outputs (K1, K2, K3, K4 and K6 for bucky selects and bucky start) may be jumper configured for a choice of the following voltages:

- 24 VDC 4 AMPS total.
- 110 VAC 2.5 AMPS total.
- 220 VAC 1.5 AMPS total.

NOTE: ***2.5 AMPS IS AVAILABLE AT 110 VAC OR 1.5 AMPS IS AVAILABLE AT 220 VAC, BUT BOTH ARE NOT AVAILABLE SIMULTANEOUSLY. TOTAL POWER CONSUMPTION MUST NOT EXCEED 350 VA.***

3B.3.3 Selecting Output Voltages (Cont)

The above voltage sources are not compatible with:

- Collimator lamps (24 VDC 150 watts). These exceed the 4 Amp rating of the 24 VDC supply.
- Fluorescent lamps. These have high starting currents and generate transients when the tube strikes.
- Some inductive loads may cause difficulties (for example some motors, under table tube fans, and solenoids).

IT IS STRONGLY RECOMMENDED THAT CLAMPING / RECOVERY DIODES BE USED ON INDUCTIVE DEVICES SUCH AS RELAYS ETC WHICH ARE CONNECTED TO THE ROOM INTERFACE BOARD.

Voltage selections are made by adding jumper wires from TB11 to TB8, TB9, or TB10, and placing the jumpers on JW1, JW2, JW3, JW4, or JW5 in the live contact position.
Review figure 3B-3 for typical examples.

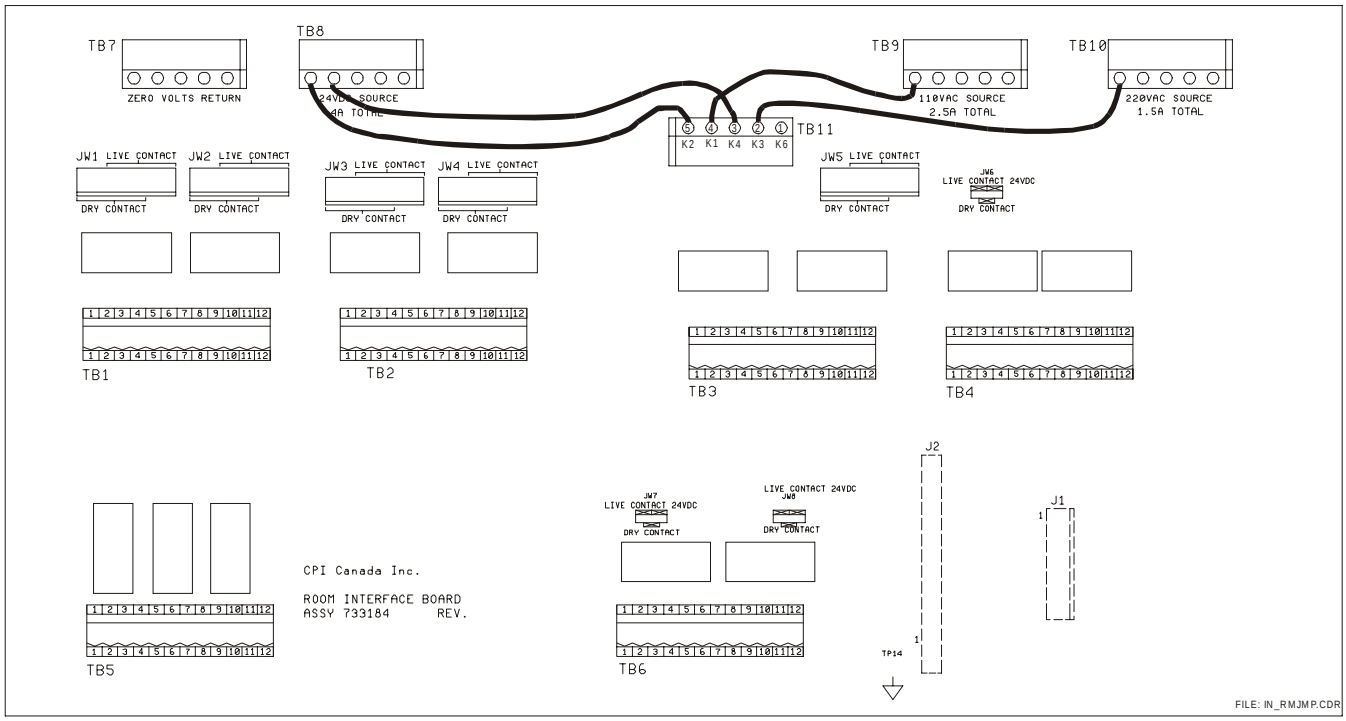


Figure 3B-3: Typical jumper arrangement on the room interface board

SOME INSTALLATIONS REQUIRE THAT THE OUTPUTS OF RELAYS K1, K2, K3, K4, K6 OR K8 DRIVE THE INPUTS OF OPTO COUPLERS. IN INSTALLATIONS WHERE THESE RELAYS SOURCE 110 OR 220 VAC, THE LEAKAGE CURRENT THROUGH THE R-C SNUBBER ACROSS THE RELAY CONTACTS MAY BE SUFFICIENT TO ENERGIZE THE OPTO COUPLERS WHEN THE RELAYS ARE OPEN.

IF THIS IS EXPERIENCED, THE R-C SNUBBER SHOULD BE DISCONNECTED FROM THE CIRCUIT. CUTTING AND REMOVING THE JUMPER WIRES PER THE TABLE ON THE NEXT PAGE WILL DISABLE THE R-C SNUBBER CIRCUIT. THE JUMPER WIRES SHOULD BE CUT AS NEAR AS POSSIBLE TO THE PADS ON THE BOARD, THEN AS MUCH AS IS POSSIBLE OF THE WIRE JUMPER SHOULD BE REMOVED. THIS IS NECESSARY TO WITHSTAND THE OPEN CIRCUIT VOLTAGE ACROSS THE RELAY CONTACTS.

3B.3.3 Selecting Output Voltages (Cont)

IT IS THE RESPONSIBILITY OF THE INSTALLER TO PROVIDE THE PROPER INTERFACING CIRCUITS TO THE OPTO COUPLER(S) IN THESE TYPES OF INSTALLATIONS.

For reference, the jumper wire links associated with each of the subject relays is listed below:

RELAY	JUMPER WIRE
K1	JW12
K2	JW9
K3	JW11
K4	JW10
K6	JW14
K8	JW13

3B.3.4 Typical Examples

Selected Output Relay	Plug and Jumper	Wire Jumper
K2 (24 VDC)	JW2: Live Contact	(K2) TB11 - 5 to TB8
K1 (110 VAC)	JW1: Live Contact	(K1) TB11 - 4 to TB9
K4 (24 VDC)	JW4: Live Contact	(K4) TB11 - 3 to TB8
K3 (220 VAC)	JW3: Live Contact	(K3) TB11 - 2 to TB10
K6 (dry contacts)	JW5: Dry Contact	(K6) TB11 - no connection
K12 (24 VDC)	JW7: Live Contact 24VDC	N/A
K13 (dry contacts)	JW8: Dry Contact	N/A
K7 (24 VDC)	JW6: Live Contact 24VDC	N/A

The previous examples will configure the outputs as shown below:

- K2 when selected will provide 24 VDC to a load at TB1 pins 11 and 12.
- K1 when selected will supply 110 VAC to a load at TB1 pins 1 and 2.
- K4 when selected will supply 24 VDC to a load at TB2 pins 11 and 12.
- K3 when selected will supply 220 VAC to a load at TB2 pins 1 and 2.
- K6 when selected will supply closed contacts at TB3 pins 11 and 12.
- K12 when selected will supply 24 VDC at TB6 pins 1 and 2.
- K13 when selected will supply closed contacts at TB6 pins 11 and 12.
- K7 will supply 24 VDC at TB4 pin 3 for tube 1, or 24 VDC at TB4 pin 2 for tube 2. Ground reference will be at TB4 pin 1.

3B.3.5 Wiring The Room Interface Terminal Plugs

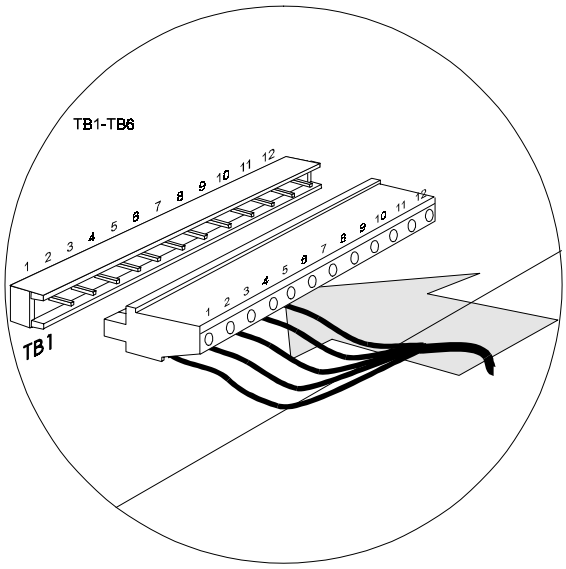


Figure 3B-4: Terminal plug

- Remove the required mating connectors from TB1 to TB6 on the room interface board.
- Back out the wire retaining screws as required.
- Dress the interface cable with a minimum of 5 inch (130 mm) flying leads.
- Strip each wire .25 inches (6 mm).
- Insert the wire into the plug and tighten the terminal screw. Several wires may be inserted into a single terminal connection.
- Be sure the plug numbering matches the input/output signals.
- Insert the plug into the room interface plug as shown in Figure 3B-4.
- Leave sufficient cable to allow interface access.
- To eliminate confusion, label each plug.
- Cover plates are located on the rear access panels to provide strain relief for the interface cables. Holes are provided on the shelf at the back of the cabinet, below the room interface board, for attaching additional strain relief hardware such as “C” or “P” clamps as desired by the installer.

3B.4.0 GENERATOR INTERFACE BOARD PROGRAMMING FOR 110/220 VAC

The 110/220 VAC supplies available at TB9 and TB10 of the room interface board may be programmed such that:

- 110/220 VAC is present at TB9 and TB10 at all times that the generator main disconnect is switched ON.
- 110/220 VAC is present at TB9 and TB10 only when the generator itself is switched ON.

The desired selection is made using JW1 on the generator interface board. Setting the jumper to JW1 pins 1-2 selects the condition where 110/220 VAC is present at TB9 and TB10 only when the generator is switched ON.

Setting the jumper to JW1 pins 2-3 selects 110/220 VAC to be present at TB9 and TB10 at all times that the generator main disconnect is switched ON.

Refer to figure 3B-5, this shows the jumper position JW1 pins 1-2 which only provides for 110/220 VAC when the generator is switched ON.

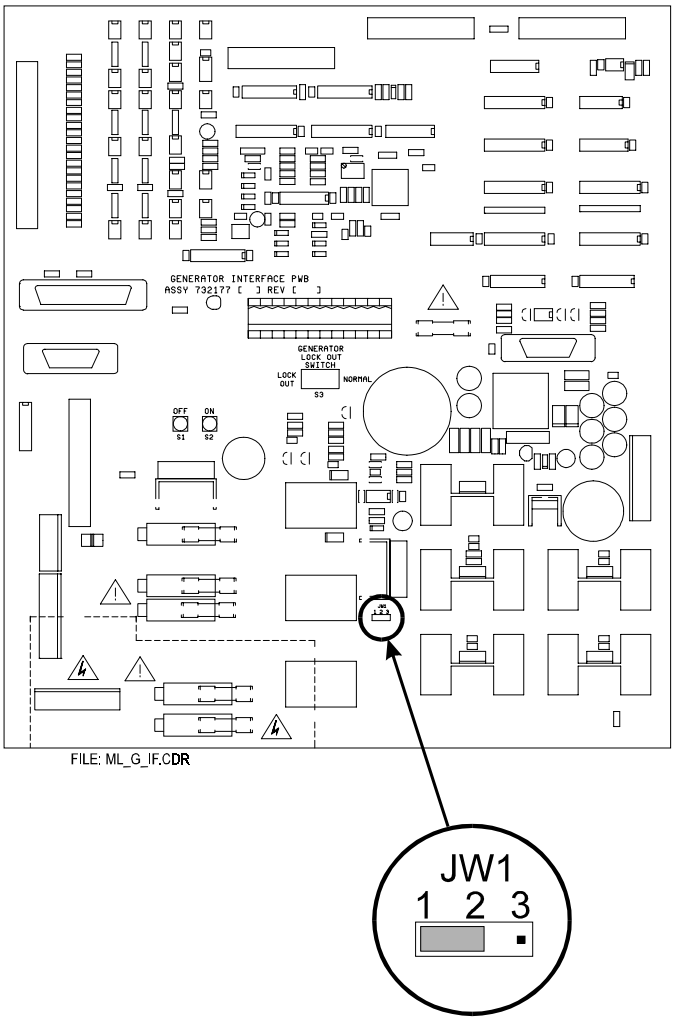


Figure 3B-5: 110/220 VAC programming

3B.5.0 TYPICAL R&F ROOM CONNECTIONS

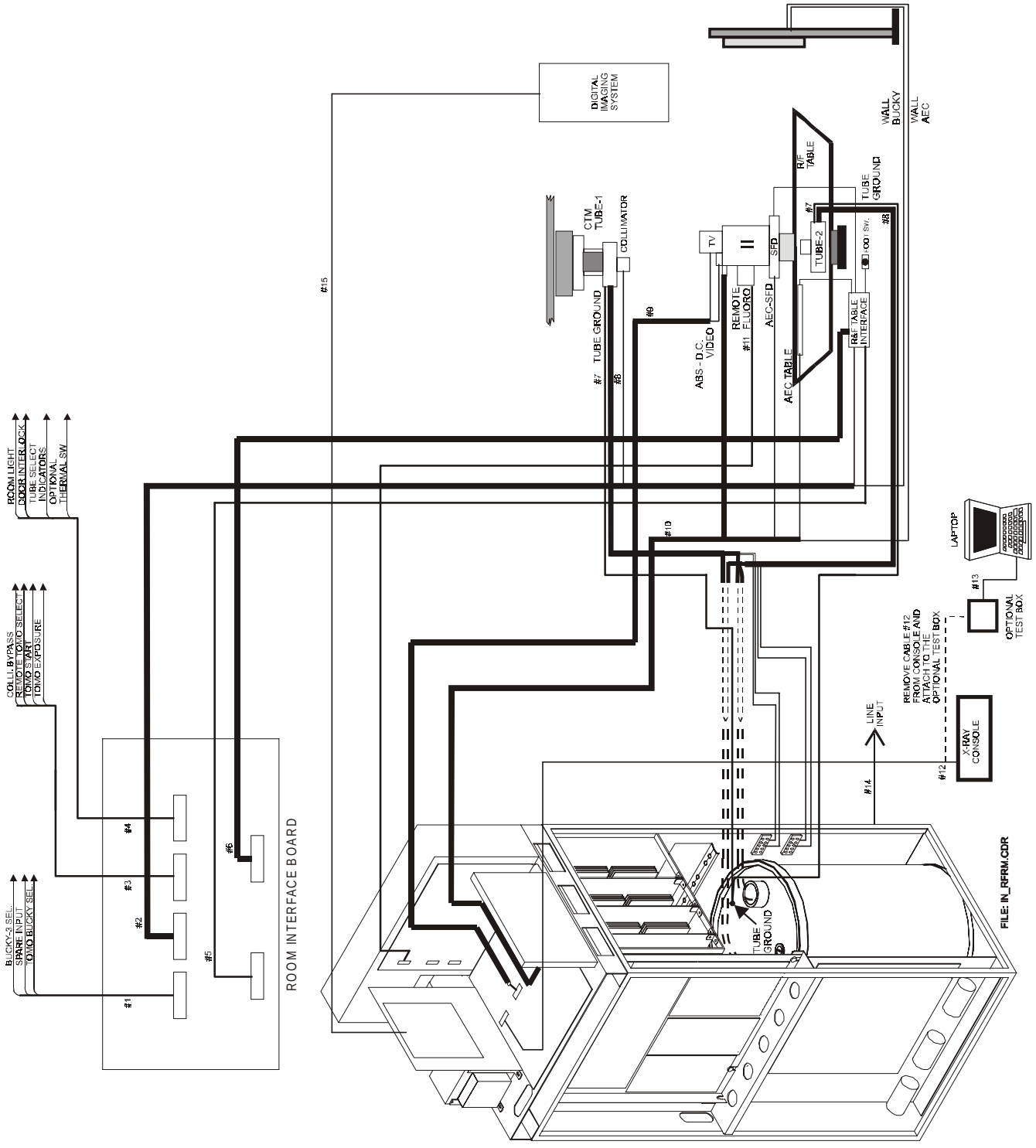


Figure 3B-6: Typical R&F room

3B.6.0 TYPICAL ROOM CABLING AND INTERFACING

The following is for reference only and represents a typical R&F procedure room.

- Cable assembly #1
  1. Bucky 3 select (image receptor).
  2. Spare input, may be programmed for an auxiliary input.
  3. Tomo bucky select, usually used to select a tomographic device.

- Cable assembly #2
  1. Bucky 1 select (image receptor), usually used to select the R&F table bucky.
  2. Collimator interlock, will prevent an exposure if the collimator inputs are not satisfied.
  3. Bucky contacts, all bucky contacts are paralleled at this connector. Diode isolation may be required.
  4. Bucky 2 select (image receptor), usually used to select vertical wall bucky.

- Cable assembly #3
  1. Collimator bypass. Usually used with the collimator associated with the tomographic device, to allow non-PBL operation in the tomographic mode.
  2. Remote tomo select, used for selecting tomography operation from a remote R&F table.
  3. Tomo start, will issue a start to sweep signal to a tomographic device.
  4. Tomographic exposure, the generator waits for a switch closure during the tomographic sweep.

- Cable assembly #4
  1. Room light. Provides a closed contact to energize the X-ray room warning light. Maximum 250 watts.
  2. Door interlock. Requires a closed dry contact to interlock the generator exposure with the X-ray room's entrance door.
  3. Tube select indicator (source select indicator). Indicates which X-ray tube has been selected.
  4. Optional thermal switch inputs.

- Cable assembly #5
  1. Mag. select. Interfaces with the image intensifier to select the magnification modes.
  2. Multiple-spot exposure. When multi-spot operation is selected at the spot film device, (example: 4 on 1) and this input receives a closed dry contact, the AEC calibration will be offset to compensate for the small fields.

- Cable assembly #6
  1. Interfaces to the table (conventional or remote R&F), the X-ray prep, expose and fluoro footswitch.
  2. The I.I. safety position interlock switch, used if the I.I. may be removed from the spot film device.
  3. ALE - required if an SFC or a serial changer is used.
  4. Spare output.

3B.6.0 TYPICAL ROOM CABLING AND INTERFACING (CONT)

- Cable assembly #7
  1. Must be a #10 AWG (6 mm^2) wire or greater, connected from the housing of both X-ray tubes to ground at the high tension transformer.

- Cable assemblies #8
  1. Pair of H.T. cables from the over table (tube-1) X-ray tube to the HT Transformer.
  2. Pair of H.T. cables from the under table (tube-2) X-ray tube to the HT transformer.

- Cable assembly #9.
  1. Interfaces the ABS signal from the TV camera as either DC proportional or composite video.
  2. Interfaces the PMT's high voltage and signal to the generator, if used.
     Refer to chapter 3E for details.

- Cable assembly #10
  1. These cables are usually supplied by the AEC vendor. Be sure these cables are placed away from any electrical noise areas. When interfacing AEC cables be careful not to cause ground loops. Grounding should **only** be at the AEC board.
     Refer to chapter 3D for details.

- Cable assembly #11
  1. This cable is supplied by CPI for the remote fluoro controller interface.

- Cable assembly #12
  1. This cable is supplied by CPI for the control console interface.

- Cable assembly #13
  1. Supplied with the optional laptop computer interconnect box.

- Cable assembly #14
  1. AC mains cable.

- Cable assembly #15
  1. Cable(s) for digital imaging system.

CHAPTER 3

SECTION 3C

PROGRAMMING THE GENERATOR

CONTENTS:

3C.1.0 INTRODUCTION

Programming of the generator is performed using the operator control console. All programming menus are displayed in the LCD display window on the console. The ten “soft key” buttons (1 to 10 in the figure below) are used to navigate through the programming screens and to select and enter values in this section.

In this section, ***SELECT*** means to press the button adjacent to the desired function shown in the LCD display window

3C.1.1 Entering Into Programming Mode

To enter into the programming mode for the generator follow the steps below. Refer to figure 3C-1 for the button locations referenced in this section. This figure depicts both the 23 X 56 (cm) console, and the 31 X 42 (cm) console.

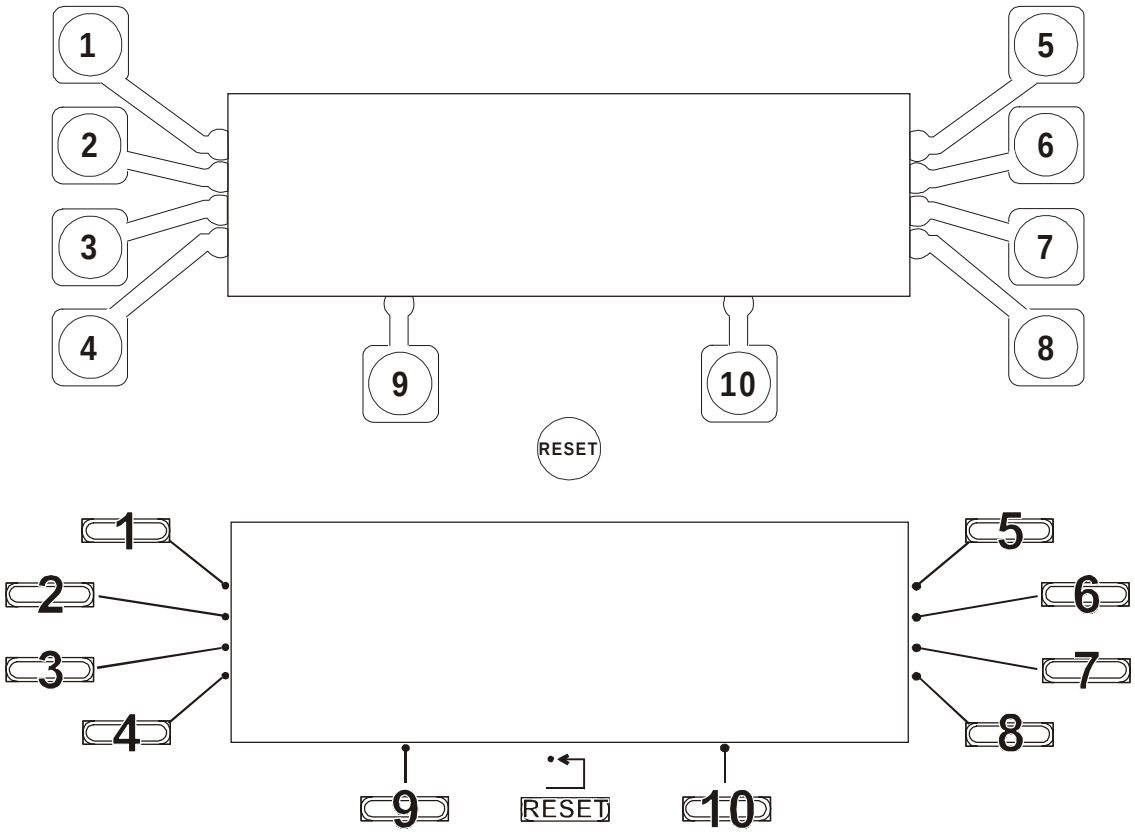


Figure 3C-1: Programming/calibration mode reference

Step	Action	Result
1.	Start with the generator switched OFF.	
2.	While pressing and holding the **RESET** button, press the generator POWER ON button on the console.	The generator will go through its start-up sequence, then display the message **ENTER PASSWORD.**
3.	Enter the password by pressing the button sequence: [**1**] - [**8**] - [**4**] - [**5**].	The **GENERATOR SETUP** menu will now be displayed as shown in the next section.

3C.2.0 GENERATOR SETUP MENU

The **GENERATOR SETUP** menu presents the user with 5 main options.

```
                * GENERATOR SETUP *
UTILITY                          APR EDITOR: ENABLED
                                 GEN CONFIGURATION
                                 DATA LINK


EXIT SETUP
```

The table below shows the functions available within each of the options in the **GENERATOR SETUP** menu. Select one of these options to access the corresponding function.

UTILITY	• Set time & date • Error log • Statistics • Console
APR EDITOR	• Enables/disables changes to APR techniques
GEN CONFIGURATION	• Tube selection • Generator limits • Receptor setup • I/O configuration • AEC setup • AEC calibration • Fluoro setup • Tube calibration
DATA LINK	• Download/upload software via a laptop computer
EXIT SETUP	• Returns to normal operating mode (non setup/programming mode)

3C.3.0 UTILITY MENU

The **UTILITY** menu presents the user with 5 options as shown below.

```
                  * UTILITY *
SET TIME & DATE
ERROR LOG
STATISTICS
CONSOLE
        EXIT
```

3C.3.1 Setting Time And Date

The **SET TIME & DATE** menu allows changing or setting of the time and date.

```
                    * SET TIME & DATE *
YEAR:   2000                                  HOUR:  18
MONTH:     9                                  MIN:   29
DAY:      15                                        +
                                                    -
          EXIT
```

Use these steps to set the time and date.

Step	Action
1.	From the **UTILITY** menu, select **SET TIME & DATE**.
2.	Select **YEAR** and press the **+** or **-** buttons to set the year.
3.	Select **MONTH** and press the **+** or **-** buttons to set the month.
4.	Select **DAY** and press the **+** or **-** buttons to set the date.
5.	Select **HOUR** and press the **+** or **-** buttons to set the hour (in 24 hour format).
6.	Select **MIN** and press the **+** or **-** buttons to set the minutes.
7.	Select **EXIT** to return to the **UTILITY** menu.

3C.3.2 Error Log

The **ERROR LOG** menu allows the display of error messages stored in the generator's error log. Parameters such as kV, mA, time, receptor, focus, tech selection, field, film screen and fluoro parameters will be displayed simultaneously on the console LED displays.

```
                    * ERROR LOG *
ERROR #   1 OF 18
DATE:    8-19-2000                        TIME: 13:09
ERROR CODE: 200                                   +
ERROR MESSAGE:   ANODE HEAT WARN                  -
          EXIT
```

Use these steps to access the error log.

Step	Action	Result
1.	From the **UTILITY** menu select **ERROR LOG.**	
2.	Select **ERROR #** and press the **+** or **-** buttons to scroll through the error log.	The error code, error message, date and time of the error will be displayed in the LCD window, and the associated parameters will be displayed on the console displays.
3.	Select **EXIT** to return to the **UTILITY** menu.	

3C.3.3 Statistics

The **STATISTICS** menu shows the tube exposure count, accumulated fluoro hours if applicable, and the accumulated generator exposure count. This also allows resetting of select counters.

* STATISTICS *		
TUBE 1 EXP:	500	RESET TUBE 1 EXP
TUBE 2 EXP:	600	RESET TUBE 2 EXP
FLUORO HOURS:	100	RESET FLUORO HOURS
TOTAL EXP:	1100	
EXIT		

Use these steps to access the statistics menu. RAD only or 1 tube generators will show a subset of the above menu items.

Step	Action
1.	From the **UTILITY** menu select **STATISTICS.**
2.	To reset the tube exposure counter, select **RESET TUBE 1 EXP** or **RESET TUBE 2 EXP**. Select **RESET FLUORO HOURS** to reset the fluoro exposure counter.
3.	Select **EXIT** to return to the **UTILITY** menu.

3C.3.4 Console

The **CONSOLE** menu allows setting of the items below to suit operator preferences:

* CONSOLE *		
SLOW KEY REPEAT:	200MS	LCD SCREEN
MED. KEY REPEAT:	150MS	APR MODE: NO
FAST KEY REPEAT:	75MS	+
SPEAKER VOLUME:	15	-
EXIT		

Definitions of console parameters as used in this section.

- **SLOW KEY REPEAT** — Determines the speed at which displays change while the selected key is pressed for the first 5 counts.
- **MED. KEY REPEAT** — Determines the speed at which displays change while the selected key is pressed for the next 5 counts.
- **FAST KEY REPEAT** — Determines the speed at which displays change while the selected key is pressed after 10 counts.
- **SPEAKER VOLUME:** — Sets the speaker volume for the control console in the range **1** to **15.**
- **LCD SCREEN** — Toggles between normal and reverse video for the LCD display.
- **APR MODE:** — **NO** allows the operator to select an APR view, while still having the ability to use the **TECH SELECT** button to manually select AEC, mAs or mA/ms.

  YES only allows the operator to use the preprogrammed technique selections for APR.

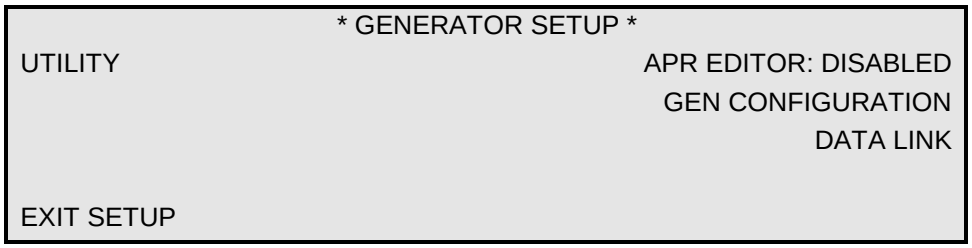
3C.3.4 Console (cont)

Use these steps to access the **CONSOLE** menu.

Step	Action
1.	From the **UTILITY** menu select **CONSOLE.**
2.	Select the desired parameter to change. SLOW, MED, FAST KEY REPEAT and SPEAKER VOLUME are adjusted by pressing the **+** or **-** buttons. LCD SCREEN and APR MODE are toggled by pressing the adjacent selection button.
3.	Select **EXIT** to return to the **UTILITY** menu.
4.	Select **EXIT** again to return to the **GENERATOR SETUP** menu.

3C.4.0 APR EDITOR

The **APR EDITOR** enables/disables the ability of the operator to make *and then save* changes to APR techniques.



Two modes of operation are available for the **APR EDITOR**:

- **ENABLED** — Allows the operator to change the default APR technique(s), and then save the changes to memory. The APR will subsequently default to the changed technique.
- **DISABLED** — Allows temporary editing of APR technique(s), but does not allow the changes to be saved to memory. The APR will always default to the original technique when the generator is switched OFF and then ON again.

GENERATORS WITH CPU BOARD 732174: When the generator is switched OFF and then ON again, the APR editor will default to the DISABLED state. Further APR changes will require that the APR editor be re- set to ENABLED to allow APR techniques to be changed and then saved.

GENERATORS WITH CPU BOARD 734573: The generator stores the last APR editor setting prior to being switched OFF. If the APR editor was previously ENABLED, APR changes may subsequently be made and then saved in normal operating mode without the need to manually set the APR editor to ENABLED. To disable APR technique changes, the APR editor must be set to DISABLED.

Use these steps to set the **APR EDITOR**.

Step	Action
1.	From the **GENERATOR SETUP** menu select **APR EDITOR**.
2.	Press the **APR EDITOR** button again to toggle to the desired selection.

3C.4.0 APR EDITOR (cont)

NOTE: ***APR TEXT MAY BE ALTERED BY USING A COMPUTER RUNNING THE CPI GenWare™ UTILITY SOFTWARE. FURTHER DOCUMENTATION REGARDING THIS FUNCTION IS INCLUDED WITH THE SOFTWARE PACKAGE IN THE FORM OF AN MS WORD DOCUMENT.***

3C.5.0 GENERATOR CONFIGURATION

The **GEN CONFIGURATION** menu presents the user with 9 options as shown below. Select one of these options to access the corresponding menu.

* GEN CONFIGURATION *	
TUBE SELECTION	AEC SETUP
GENERATOR LIMITS	AEC CALIBRATION
RECEPTOR SETUP	FLUORO SETUP
I/O CONFIGURATION	TUBE CALIBRATION
EXIT	

3C.5.1 Tube Selection

The **TUBE SELECTION** menus allow the desired tube type to be selected and assigned to TUBE 1 and to TUBE 2 (two tube generators only), and allow setting of the default limits for that tube.

This menu will not be displayed on one-tube generators.

*TUBE SELECTION *
TUBE 1
TUBE 2
EXIT

The next three menus display the default tube selections. Selections may not be exactly as shown.

* TUBE 1 SELECTION *	
A192B 0.6/1.2	G256 0.6/1.0
A256 0.6/1.0	G292 0.6/1.2
A292 0.6/1.2	G1082 0.3/1.0
A272 0.3/0.6	RAD8 1.0/2.0
RETURN	>>

* TUBE 1 SELECTION *	
RAD14 0.6/1.2	RAD74 0.6/1.5
RAD21 0.6/1.2	RAD92 0.6/1.2
RAD56 0.6/1.2	DX10HS 0.6/1.0
RAD60 0.6/1.2	DX92HS 0.6/1.2
<<	>>

3C.5.1 Tube Selection (cont)

```
                    * TUBE 1 SELECTION *
DX93HS  0.6/1.5                 RO1750  0.6/1.3
DX101HS  0.6/1.3
MX75  1.0/2.0
MX100  0.6/1.25
        <<                                  >>
```

This menu is only available if additional tubes have been downloaded via a computer running CPI GenWare™ software.

```
                    * TUBE 1 SELECTION *

          ***USER DOWNLOADED TUBES DISPLAYED HERE**


        <<                                  RETURN
```

Use these steps to access the **TUBE SELECTION** menus.

Step	Action	Result
1.	From the **GEN CONFIGURATION** menu select **TUBE SELECTION**.	
2.	Select **TUBE 1** or **TUBE 2**. This step not available on one tube generators, go directly to step 3.	The available tubes to choose from will display.
3.	Select the X-ray tube type to be assigned to that tube location. Use the **>>** and **<<** buttons to navigate through the tube selection menus if your desired tube is not displayed on the current screen.	This will assign the selected X-ray tube to the desired tube location.
4.	Once the desired tube has been selected, parameters for that tube are displayed showing the default values. DO NOT adjust the default values at this time.	See next page for further details. Do not press **RETURN** or **>>** until this is requested in a later step.
5.	Additional tube types may be downloaded using the CPI GenWare™ utility software. Refer to section 3C.6.0 **DATA LINK.**	

When the desired tube is selected, the default limits are displayed. Please consult the X-ray tube data sheet(s) before making any changes.

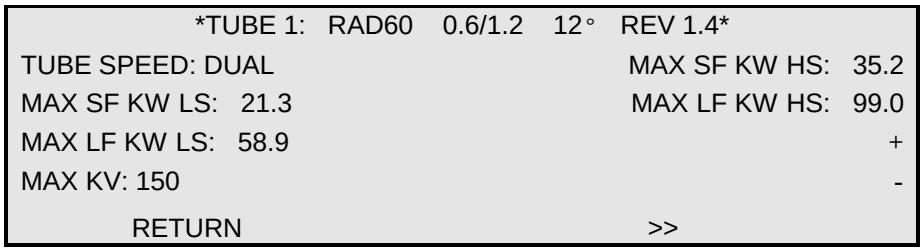
The dual speed starter operates at 60 or 180 Hz (50 or 150 Hz for some tube types) independent of line frequency. The low speed starter operates at 50 Hz for 50 Hz mains, or 60 Hz for 60 Hz mains. Therefore for generators equipped with the low speed starter, the 60 Hz tube ratings are automatically derated for 50 Hz operation if required.

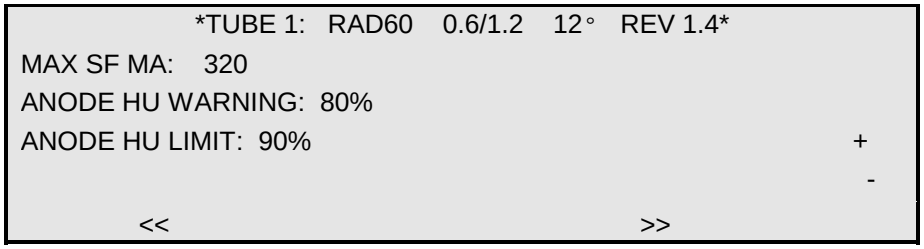
PLEASE DO NOT CHANGE ANY DEFAULTS UNLESS THE IMPACT OF THOSE CHANGES IS CLEARLY UNDERSTOOD. INITIAL CALIBRATION SHOULD BE PERFORMED USING THE DEFAULT VALUES.

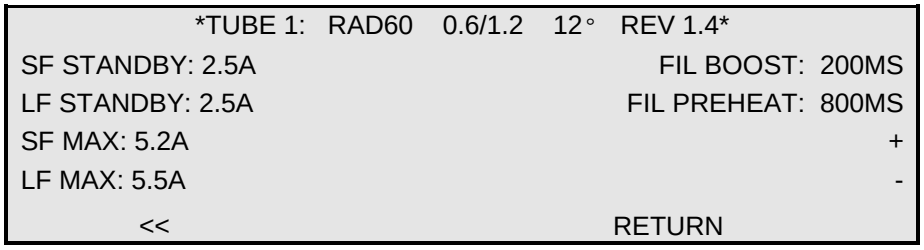
3C.5.1 Tube Selection (cont)

NOTE: ***BEFORE CHANGING X-RAY TUBE DEFAULT PARAMETERS, PLEASE FILL IN THE X-RAY TUBE AND GENERATOR PARAMETER WORKSHEET. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A 3.0. THIS ALLOWS RECORDING OF THE DEFAULT VALUES AND THE NEW (CHANGED) VALUES.***

The next three menus show the default tube limits. These menus appear after a tube has been selected in the previous steps.







Definitions of tube defaults as used in this section.

- **TUBE SPEED** — May be altered on dual speed generators. **DUAL** means that the *generator* determines whether to use low speed or high speed operation.
- **MAX SF KW LS** — Sets the maximum small focus low speed kW limit.
- **MAX LF KW LS** — Sets the maximum large focus low speed kW limit.
- **MAX KV**: — Sets the maximum kV allowed for that tube.
- **MAX SF KW HS** — Sets the maximum small focus high speed kW limit.
- **MAX LF KW HS**: — Sets the maximum large focus high speed kW limit.

3C.5.1 Tube Selection (cont)

- **MAX SF MA** Sets the maximum mA in small focus. This should be set as low as possible to preserve the focal spot track wear and focal spot blooming.
- **ANODE HU WARNING** Sets the limit at which the anode heat warning message is displayed.
- **ANODE HU LIMIT** Sets the limit at which exposures will be inhibited. If the present anode heating is under the threshold, the exposure will be inhibited if the next exposure is calculated to exceed the anode HU limit.
- **SF STANDBY** Sets the small focus standby filament current. The required value should be obtained from the X-ray tube data sheets.
- **LF STANDBY** As above but for large focus.
- **SF MAX** Sets the small focus maximum filament current.
- **LF MAX** As above but for large focus.
- **FIL BOOST** Sets the filament rapid boost duration in order to quickly raise the filament temperature. In installations where a spot film or equivalent device is used, default boost and preheat values may be decreased if needed to allow for one second R/F change over time.
- **FIL PREHEAT** The time that the filament is held at the required emission level before an exposure is permitted

Typically, the boost time should be between 200 and 250 msec, and the preheat time should be in the range of 700 - 800 ms.
If in doubt, monitor the filament feedback and be sure the filament is not being over or under driven ***during an exposure.***

Standby current must be below the emission point. If the standby current is too high, the lower fluoro mA may not calibrate properly resulting in a high mA fault error during fluoro operation.

If the maximum filament current is increased, be careful not to exceed the tube manufacturer's specifications.

Use these steps to modify the tube defaults.

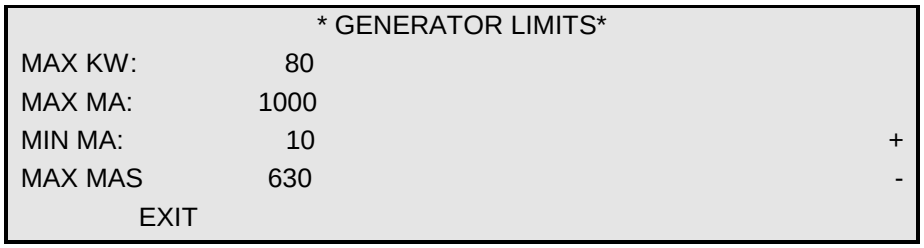
Step	Action
1.	Use the **>>**, **<<**, and **RETURN** buttons to navigate through the TUBE DEFAULTS screens.
2.	Select the appropriate default value to change. Refer to the definitions on the previous page.
3.	Use the **+** and **-** buttons to change the selected values. Pressing the **TUBE SPEED** button toggles the selection between LOW, HIGH and DUAL speed (generators with dual speed starter only).
4.	When finished altering the tube default values, press the **<<, RETURN** or **EXIT** button(s) as required to return to the **TUBE SELECTION** menu (two tube generators) or **GEN CONFIGURATION** menu (one tube generators).

3C.5.1 Tube Selection (cont)

5.	Select the second X-ray tube if desired by repeating the previous steps (two tube generators only).
PLEASE ENSURE THAT THE SELECTED X-RAY TUBE STATOR(S) ARE COMPATIBLE WITH THE LOW SPEED OR DUAL SPEED STARTER IN YOUR GENERATOR.	
6.	Select **EXIT** to return to the **GEN CONFIGURATION** menu (two tube generators only).

3C.5.2 Generator Limits

The **GENERATOR LIMITS** menu allows the setting of generator limits as defined below.



Definitions of generator limits as used in this section.

- **MAX KW** Sets the maximum generator kW limit.
- **MAX MA** Sets the maximum generator mA limit.
- **MIN MA** Sets the minimum generator mA limit.
- **MAX MAS** Sets the maximum generator mAs limit.

BEFORE MAKING ANY CHANGES IN THIS SECTION, PLEASE CONSULT THE X-RAY TUBE DATA SHEETS TO ENSURE THAT THE PROPOSED CHANGES DO NOT EXCEED THE MANUFACTURERS RECOMMENDED LIMITS.

NOTE: ***BEFORE CHANGING GENERATOR LIMITS, PLEASE FILL IN THE X-RAY TUBE AND GENERATOR PARAMETER WORKSHEET. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A 3.0. THIS ALLOWS RECORDING OF THE DEFAULT VALUES AND THE NEW (CHANGED) VALUES.***

Use these steps to set the generator limits.

Step	Action
1.	From the **GEN CONFIGURATION** menu select **GENERATOR LIMITS.**
2.	Select a limit to be changed. Refer to the previous definitions.
3.	Use the **+** and **-** buttons to change the selected values.
4.	When finished altering the generator default values, press **EXIT** to return to the **GEN CONFIGURATION** menu.

3C.5.3 Receptor Setup

The **RECEPTOR SETUP** menus allow each of the image receptors to be programmed as defined in the table following the example menu screens.

```
                * RECEPTOR  SETUP [sym] *
TUBE:    1                              AEC CHANNEL: 1
TOMO: NO                            INTERFACE OPTS: 0
FLUORO: NO                                        +
SERIAL:   NO                                      -
          EXIT                          >>
```

```
                * RECEPTOR SETUP [sym]*
RECEPTOR SYM: [sym]                       MEMORY: DEF
FLUORO HANG:   30 SEC              REM TOMO BUT: 2000 MS
RAD HANG:  0 SEC                                  +
LAST IMAGE HOLD:   40 MS                          -
          <<                            >>
```

```
                * RECEPTOR SETUP [sym]*
SF/LF SWITCH:  MAN                          DEFAULTS
AEC BACKUP:   FIXED
AEC BACKUP MAS:  500                              +
AEC BACKUP MS:  3200                              -
          <<
```

*THE **DEFAULTS** SELECTION IN THE MENU ABOVE IS ONLY AVAILABLE IF **MEMORY** IN MENU 2 WAS SET TO **DEF.***
*RECEPTOR MENUS 4 AND 5 BELOW ARE ONLY ACCESSIBLE IF **DEFAULTS** IS ENABLED.*

```
            * RECEPTOR SETUP [sym] DEFAULTS*
TECHNIQUE: AEC                          LEFT FIELD: YES
FOCUS: SMALL                          CENTER FIELD: YES
FILM SCREEN: 1                         RIGHT FIELD: YES


          <<                            >>
```

```
            * RECEPTOR SETUP [sym] DEFAULTS*
KV:       75                                DENSITY:   0
MA:      320
MS:       50                                        +
                                                    -

          <<
```

3C.5.3 Receptor Setup (cont)

Definitions of receptor setup programming as used in this section follow. The selections made when programming a receptor apply to that receptor only.

- **TUBE** — Selects the tube assigned to that receptor. Selecting **NONE** disables that receptor.
- **TOMO** — Enables or disables tomographic operation (**NO** is disabled).
- **FLUORO** — Enables or disables fluoroscopic operation (**NO** is disabled).
- **SERIAL** — Allows repeated (serial) X-ray exposures without the need to re-prep after each exposure. Normally used with serial film changers (**NO** is disabled).
- **AEC CHANNEL** — Defines which AEC channel will be used by the receptor. This must be set to a valid channel or **0** as noted below. For example if using an AEC board with only 3 input channels (channels 1 to 3) then selecting AEC channel 4 will cause an error. Selecting **0** disables AEC operation on that receptor.
- **INTERFACE OPTS** — Selects pre-defined interface options:

  0 = None

  1 = InfiMed digital

  2 = ATS ESI digital

  3 = Gilardoni digital pulsed RAD

  4 = Gilardoni digital HCF

  5 = Not assigned at this time
- **RECEPTOR SYM** — Allows one of six receptor symbols **[sym]** to be associated with the selected receptor. Symbol 7 is blank and may be used for an auxiliary device.
- **FLUORO HANG** — Sets the time that the rotor will continue spinning after a fluoro exposure has terminated.
- **RAD HANG** — Sets the time that the rotor will continue spinning after a rad exposure has terminated.
- **LAST IMAGE HOLD** — Sets the time that the exposure will continue after the fluoro footswitch has been released. This enables a frame store device to complete the last image.
- **MEMORY** — Defines the techniques that will be defaulted to when a receptor is selected:

  YES: The selected receptor will remember it's last techniques such that those techniques are displayed when that receptor is re-selected.

  NO: The selected receptor will not remember the last techniques used on that receptor. The techniques used will be the same as last used on the previous receptor.

  DEF: The techniques used for that receptor will be as programmed. See receptor setup menu 4 and 5

3C.5.3 Receptor Setup (cont)

- **REM TOMO BUT** — Sets the default tomo backup time when tomo is selected via the REMOTE TOMO SELECT input.
- **SF/LF SWITCH** — **AUTO:** Small or large focus will automatically be selected by the generator depending on the tube current.

  MAN: The operator must manually select small/large focus.
- **AEC BACKUP** — Defines the AEC backup mode to be used:

  FIXED: The generator will determine the maximum AEC backup time, not to exceed preset AEC backup mAs/ms values or system limits. The characters **AEC** will be displayed in the time window of the LED display during AEC operation.

  MAS: Allows the operator to adjust the AEC backup mAs, not to exceed preset AEC backup mAs/ms values or system limits. The mAs value will be displayed in the time window of the LED display during AEC operation.

  MS: Allows the operator to adjust the AEC backup ms, not to exceed preset AEC backup mAs/ms values or system limits. The ms value will be displayed in the time window of the LED display during AEC operation.
- **AEC BACKUP MAS** — Sets the maximum backup mAs, to a limit of 500 mAs (600 mAs for some generator models).
- **AEC BACKUP MS** — Sets the maximum back-up ms.
- **DEFAULTS** — This selection is available only if **MEMORY** was set to **DEF** in RECEPTOR SETUP menu 2.

THE FOLLOWING SELECTIONS ARE ONLY AVAILABLE IF DEFAULTS WAS ENABLED AS PREVIOUSLY DESCRIBED.

- **TECHNIQUE** — Defines which technique will be defaulted to when a receptor is selected. Options are **AEC, MA, MAS**.
- **FOCUS** — Defines which focus will be defaulted to when a receptor is selected. Options are **LARGE** or **SMALL**.
- **FILM SCREEN** — Defines which film screen will be defaulted to when a receptor is selected and AEC enabled. Options are film screen **1**, **2**, or **3**.
- **LEFT FIELD** — Selects the left field on the AEC device when AEC is selected.
- **CENTER FIELD** — As above, but for center field.
- **RIGHT FIELD** — As above, but for right field.
- **KV** — Selects the default kV value.
- **MA** — Selects the default mA value.
- **MS** — Selects the default time value.
- **DENSITY** — Selects the default density value.

3C.5.3 Receptor Setup (cont)

NOTE: ***IT IS RECOMMENDED THAT THE IMAGE RECEPTOR PROGRAMMING WORKSHEET BE FILLED IN FOR EACH RECEPTOR THAT IS PROGRAMMED. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A 4.0. THIS WILL PROVIDE A RECORD OF THE RECEPTOR SETUP FOR FUTURE REFERENCE.***

If the image receptor defaults are changed, please record the original defaults in a copy of the table below:

IMAGE RECEPTOR DEFAULT SETTINGS						
FUNCTION	**RECEPTOR 1**	**RECEPTOR 2**	**RECEPTOR 3**	**RECEPTOR 4**	**RECEPTOR 5**	**RECEPTOR 6**
TECHNIQUE						
FOCUS						
FILM SCREEN						
LEFT FIELD						
CENTER FIELD						
RIGHT FIELD						
KV						
MA						
MS						
DENSITY						

NOTE: ***DO NOT SWITCH OFF THE GENERATOR WHILE IN *RECEPTOR SETUP [SYM] DEFAULTS* MENUS 4 AND 5. DOING SO WILL CAUSE THE UPDATED RECEPTOR SETUP PARAMETERS NOT TO BE SAVED. IT IS RECOMMENDED THAT THE FIRST RECEPTOR PROGRAMMING BE COMPLETED, THE RECEPTOR SETUP MENUS BE EXITED TO THE GEN CONFIGURATION MENU, THEN THE RECEPTOR SETUP MENU BE RESELECTED TO PROGRAM THE NEXT RECEPTOR. THE ABOVE SHOULD BE REPEATED UNTIL ALL RECEPTORS ARE PROGRAMMED. THIS WILL ENSURE THAT THE UPDATED PARAMETERS ARE SAVED.***

Use these steps to set up the receptor parameters.

Step	Action
1.	From the **GEN CONFIGURATION** menu select **RECEPTOR SETUP**.
2.	Select the desired receptor to be programmed.
3.	Use the **NEXT**, and **BACK** buttons to navigate through the screens. As noted earlier, the **RECEPTOR SETUP [SYM] DEFAULTS** menus (if enabled) are accessed by selecting **DEFAULTS** in screen 3.
4.	Select the appropriate parameter to change. Refer to the definitions on the previous pages in this section.

3C.5.3 Receptor Setup (cont)

5.	Certain selections are toggled (press the selection button again to change the value), other parameters must be selected via the adjacent selection button. The values are then changed using the **+** and **-** buttons.
6.	When finished setting the parameters and/or defaults for the current receptor, press the **<<** or **EXIT** button(s) as required to return to the **GEN CONFIGURATION** menu.
7.	Reselect **RECEPTOR SETUP**, then select the next receptor to be programmed.
8.	When finished programming all receptors, return to the **GEN CONFIGURATION** menu as per step 6.

3C.5.4 I/O Configuration

The **I/O CONFIGURATION** menus allow programming the states of exposure for the inputs and the outputs on the room interface board.

```
                    * INPUTS [sym] *
REMOTE EXP :       ..._..._..._..        STANDBY STATE
REMOTE PREP:       ..._...........
REMOTE FL. EXP:    ..............---
CONSOLE  EXP:      ...---...---...
        EXIT          ⇑                  >>
```

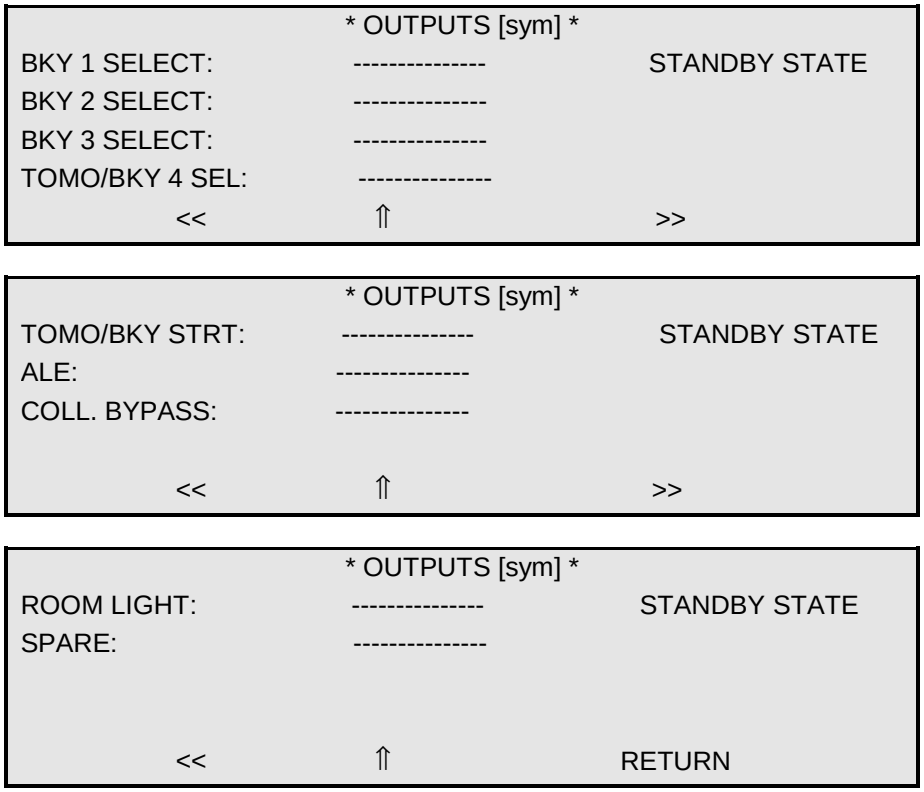
```
                    * INPUTS [sym] *
CONSOLE PREP:      ...---.........        STANDBY STATE
TOMO EXP:          ........ ---...
REM. TOMO SEL.:    ---.............
I/I SAFETY:        ...---...------
        <<            ⇑                  >>
```

```
                    * INPUTS [sym] *
COLL. ITLK:        ...---...------        STANDBY STATE
BUCKY CONTACTS:    .........---...
SPARE:             ------...------
THERMAL SW 1:      ------...------
        <<            ⇑                  >>
```

```
                    * INPUTS [sym] *
THERMAL SW 2:      -----...-----          STANDBY STATE
DOOR ITLK:         ----- ...-----
MULTI SPOT EXP:    ---.............


        <<            ⇑                  >>
```

3C.5.4 I/O Configuration (cont)



The **STATE** button on the upper right hand side of the menu selects the current state. The word **STATE** will be preceded by the description of the state: for example, **STANDBY**.

The arrow in the lower middle area points to one of the five states described below. Moving to the next state is accomplished by pressing the **STATE** button. The states are as follows:

- **STANDBY** — Sets state of the I/O when the generator is in standby or idle mode. Standby mode also defines the state when the generator is in fluoroscopic hangover.
- **PREP** — Sets state of the I/O when the generator first enters PREP mode.
- **GEN RDY** — Sets state of the I/O when the generator has completed PREP mode and is ready to expose.
- **RAD EXP** — Sets state of the I/O when the generator starts a radiographic exposure.
- **FLUORO EXP** — Sets state of the I/O when the generator starts a fluoroscopic exposure.

3C.5.4 I/O Configuration (cont)

Pressing one of the buttons next to the selected function on the left of the display selects that function. The logic level of the selected state is then changed by pressing the selection button again (low = off/inactive, high = on/active).

For inputs, a logic "low" means that the input is ignored during that state. A Logic "high" requires that the input be satisfied before the generator will advance to the next state. If multiple inputs are programmed "high", for example if REMOTE PREP and CONSOLE PREP are both high in the prep state, then both inputs will need to be active before the generator will enter the prep state.

Setting an output to logic "low" causes the relay associated with that output to be de-energized during the selected state. Logic "high" will cause the associated relay to be energized during the selected state.

Certain functions have states indicated by a dotted line. The dotted line indicates invalid states, which cannot be altered. Only states shown by a solid line can be changed. Refer to figure 3C-2 for examples of a TYPICAL input configuration.

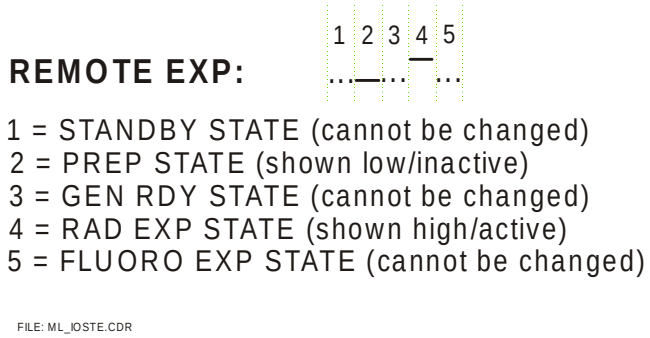


Figure 3C-2: Example of input states

NOTE: ***IT IS RECOMMENDED THAT THE I/O CONFIGURATION WORKSHEET BE FILLED IN FOR EACH INPUT OR OUTPUT THAT IS PROGRAMMED. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A.5.0. THIS WILL PROVIDE A RECORD OF THE I/O CONFIGURATION FOR FUTURE REFERENCE.***

Use these steps for programming the I/O functions

Step	Action
1.	From the **GEN CONFIGURATION** menu, select **I/O CONFIGURATION**.
2.	Select the desired receptor to be programmed.
3.	Select the desired input(s) or output(s) to program. Use the **>>, <<,** and **RETURN** buttons to navigate through the screens.
4.	Press the **STATE** button to cycle through and select the desired state to program.
5.	Select the function to be programmed (example **REMOTE EXP**). Press the selection button again to change the logic level for that state. States with dashed lines (...) *CANNOT BE CHANGED*.
6.	Repeat steps 4 and 5 for each state in the selected I/O function.
7.	Repeat steps 3 to 6 for each input or output to be programmed.
8.	When finished the I/O programming for the current receptor, press the **<<** or **EXIT** button(s) as required to return to the **GEN CONFIGURATION** menu.
9.	Reselect **I/O CONFIGURATION,** then select the next receptor to be programmed.
10.	When finished programming all receptors, return to the **GEN CONFIGURATION** menu as per step 8.

3C.5.5 AEC Setup

The **AEC SETUP** menu allows the setting of AEC parameters for each AEC channel.

```
                    * AEC SETUP*
CHANNEL:    1                          CHAMBER TYPE:  ION
LEFT FIELD:       YES                  FILM SCREEN 1 : YES
CENTER FIELD:     YES                  FILM SCREEN 2 : YES
RIGHT FIELD:      YES                  FILM SCREEN 3 : YES
          EXIT
```

Definitions of **AEC SETUP** parameters as used in this section.

- **CHANNEL** Selects the AEC channel to be programmed.
- **LEFT FIELD** Enables or disables the left field for the selected AEC channel (**NO** is disabled).
- **CENTER FIELD** As above but for center field.
- **RIGHT FIELD** As above but for right field.
- **CHAMBER TYPE** Selects **ION CHAMBER** or SOLID STATE (**S/S**) chamber for the selected AEC channel.
- **FILM SCREEN 1** Enables or disables the selection of FILM SCREEN 1 for that AEC channel (**NO** is disabled).
- **FILM SCREEN 2** As above but for film screen 2.
- **FILM SCREEN 3** As above but for film screen 2.

Use these steps to perform the **AEC SETUP**.

Step	Action
1.	From the **GEN CONFIGURATION** menu select **AEC SETUP**.
2.	Select the AEC channel to be setup. Pressing the **CHANNEL** button will scroll through the available AEC channels.
3.	Select the desired parameter to change.
4.	Press the selection button for that parameter to toggle the available selections.
5.	Repeat steps 2 to 4 to program each AEC channel.
6.	When finished the **AEC SETUP,** press **EXIT** to return to the **GEN CONFIGURATION** menu.

3C.5.6 AEC Calibration

Refer to chapter 3 section 3D, AEC CALIBRATION.

3C.5.7 Fluoro Setup

Refer to chapter 3 section 3E, ABS CALIBRATION.

3C.5.8 Tube Calibration

Refer to chapter 2, the section TUBE AUTO CALIBRATION.

3C.6.0 DATA LINK

This is used with the CPI GenWare™ utility software. This allows for data communication with a computer in order to download additional tube types, transfer APR data, run the A^2EC^2 ™ utility, and for other minor functions. Further documentation is included with the software package in the form of an MS word document (MANUAL.DOC).

A computer (i.e. laptop) and a 9 pin null modem cable with socket connectors (female) on both ends are required to run this software and interface to the generator.

CHAPTER 3

SECTION 3D

AEC CALIBRATION

CONTENTS:

3D.1.0 INTRODUCTION

This section covers interfacing and calibration of the various AEC board assemblies that are used in Millenia and Indico 100 generators (for ion chambers, solid state chambers or PMT pickups).

PLEASE NOTE THAT THE GENERATOR IS FACTORY CONFIGURED FOR A SPECIFIC AEC DEVICE(S). REFER TO THE CUSTOMER PRODUCT DESCRIPTION FORM IN CHAPTER 1 SECTION D FOR THE FACTORY CONFIGURED AEC COMPATIBILITY OF THIS GENERATOR.

The introduction in this section contains background information relevant to AEC operation. It is strongly suggested that this be read and understood prior to beginning AEC calibration.

AEC calibration requires that a calibration curve be established which relates optical density to various kV breakpoints.

The 75 kV knee breakpoint is calibrated at the slowest film screen combination. The remaining kV breakpoints are calibrated next, then the breakpoint calibration is repeated at the next highest film speed, with the highest film speed being calibrated last.

After breakpoint calibration, ± density setup is done at the slowest film speed, then RLF compensation and multiple spot compensation are done if desired.

3D.1.1 $A^2EC^{2\ TM}$ (Automated Automatic Exposure Control Calibration)

The optional $A^2EC^{2\ TM}$ kit automates most of the AEC calibration functions, simplifying and reducing AEC calibration time by up to 80%. The kit consists of a photo detector which is placed inside the film cassette, a preamplifier, interface cabling and adapters, $A^2EC^{2\ TM}$ software, and an $A^2EC^{2\ TM}$ instruction manual all packaged in a convenient carrying case.

The $A^2EC^{2\ TM}$ system must be used in conjunction with the CPI GenWare™ utility software. Refer to the section DATA LINK at the end of chapter 3C for information on equipment required to run the GenWare™ software.

Please contact the factory for further information.

3D.1.2 AEC Limitations: Minimum Response Time

The X-ray generator (including the AEC pickup chamber) has a minimum response time from start of the exposure command to a kV value sufficient to start X-rays. There is a further delay to the start of current flow from the AEC device. Likewise, there is a minimum response time from when the AEC stop command is issued to when the kV has actually decreased to the point that X-rays are no longer produced. Figure 3D-1 depicts this graphically.

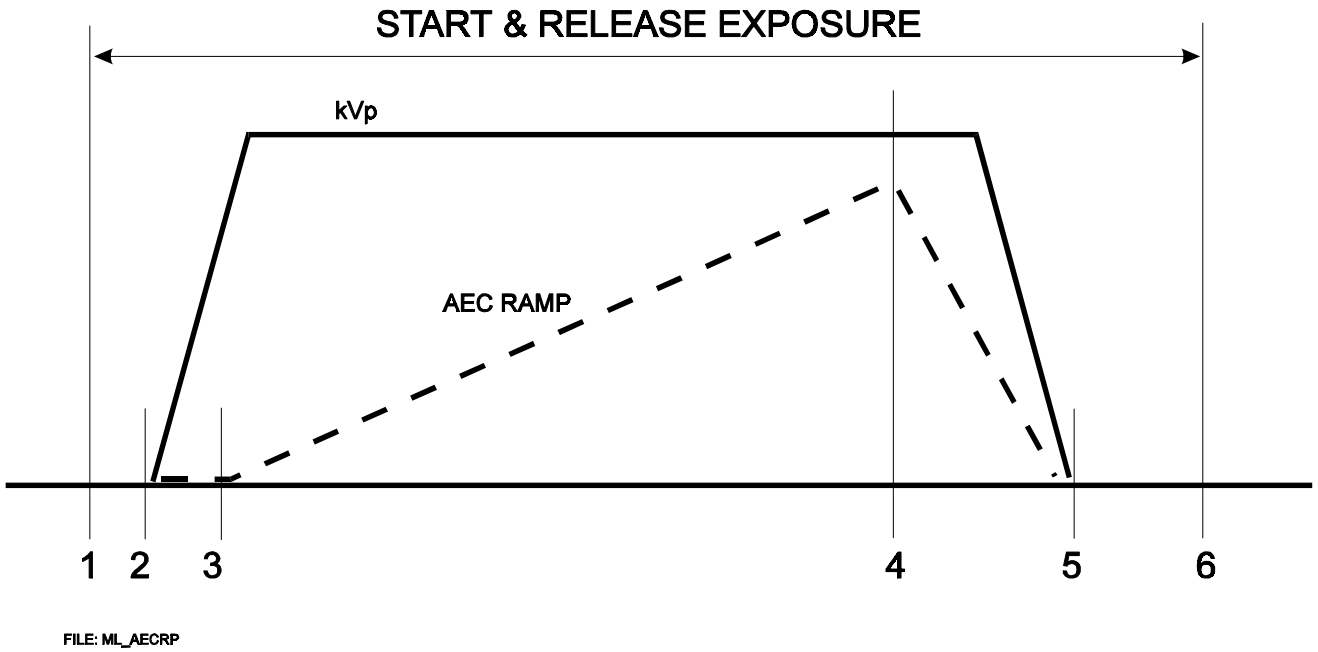


Figure 3D-1: Relative timing of AEC ramp vs exposure command and kVp

- 1 to 2 is the time from the exposure start command to kVp start.
  Time = 1 to 3 ms.
- 2 to 3 is the reaction time of the solid state/ion chamber to start a current flow.
  Time = 1 to 3 ms.
- 3 to 4 is the required exposure time.
- 4 is the AEC stop command from the generator AEC circuits.
- 4 to 5 is the generator shut down time including cable discharge time etc.
  Time = 1.5 to 3.0 ms.
- 1 to 6 is the total time the exposure switch is activated.
- **FOR AEC BOARDS WITH SHORT AEC TIME COMPENSATION (FIGURE 3D-9 AND 3D-11) AEC TECHNIQUES SHOULD HAVE MINIMUM EXPOSURE TIMES GREATER THAN 5 MS. FOR ALL OTHER AEC BOARDS MINIMUM EXPOSURE TIMES SHOULD BE GREATER THAN 15 MS.**

3D.1.3 AEC Limitations: Maximum Exposure Times

AEC exposures should normally be kept well under one second. When X-ray techniques are used that result in longer exposures, the film density will not be correct due to failure of reciprocity of the film.

RLF (reciprocity law failure) compensation is provided to compensate for longer AEC exposure times. An offset may be added to each AEC calibration set (each film screen combination) to increase the AEC ON time as exposure time increases. RLF compensation is applied to the following range of times:

- 50 ms to 500 ms
- 500 ms to 1000 ms
- 1000 ms and above.

Care must be exercised when using table buckys with low kV values because most table tops and grids absorb considerable radiation in the range of 60 - 65 kVp. This will adversely affect AEC operation.

Figure 3D-2 shows the effect of kVp, optical density, and radiation. Note particularly the nonlinear change in density at 85-90 kVp.

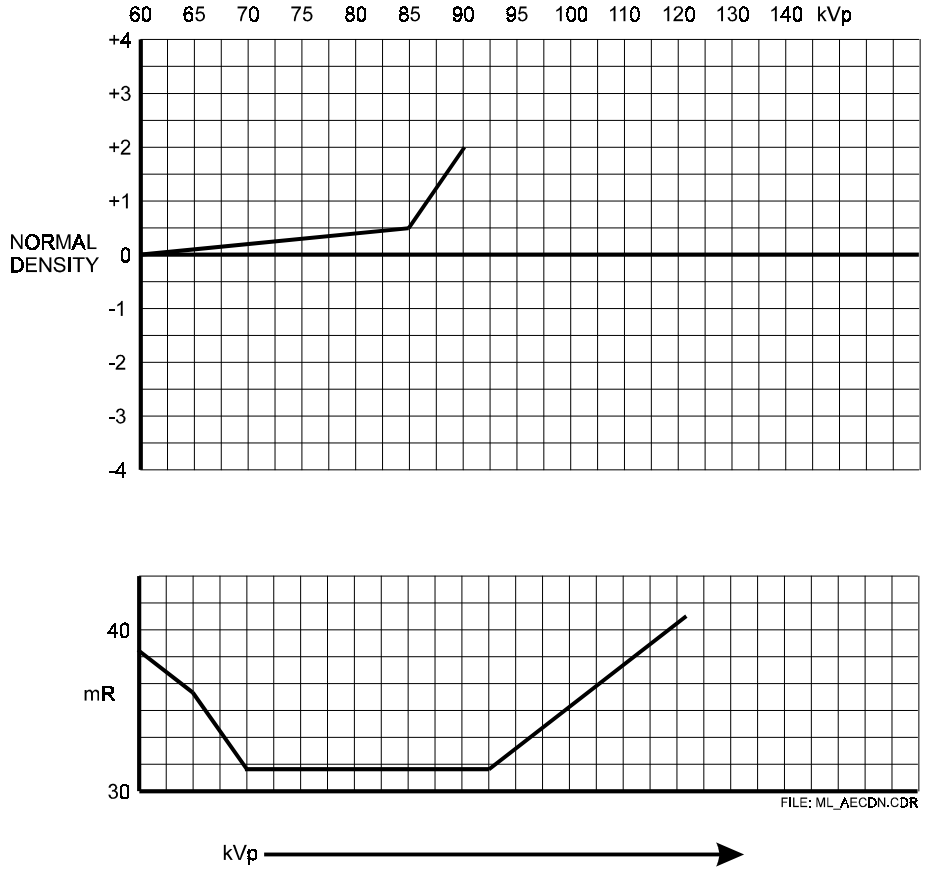


Figure 3D-2: kVp vs optical density vs dose

3D.1.4 Film/Screen Response vs kVp

Film screen response to kVp is not linear, therefore compensation must be provided in order to maintain constant film density as kVp is changed for different anatomical studies. By selecting and calibrating various kV breakpoints, the overall system response will be compensated such as to yield a constant film density.

Up to eight breakpoints per film screen combination are available. The eight breakpoints are spread over three kV ranges as shown below:

- Low kV: 50, 55, 65 kV
- Knee kV: 75 kV
- High kV: 85, 95, 110, 130 kV.

Refer to figure 3D-3.

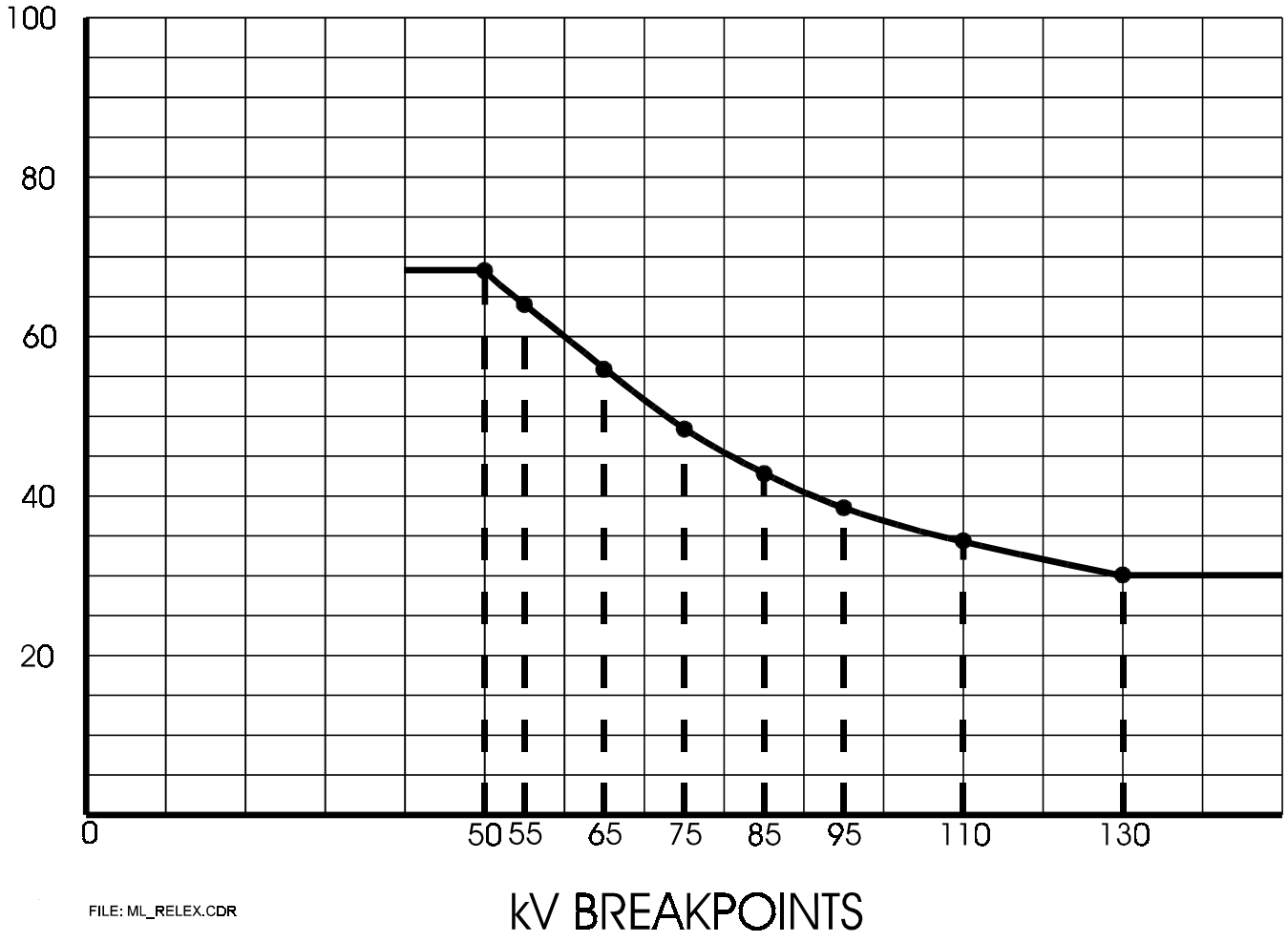


Figure 3D-3: kV breakpoints vs relative density

3D.1.5 AEC Calibration Range

Since the Millenia and Indico 100 family of generators allow for up to three separate film screen combinations to be calibrated, the following points must be considered :

- The AEC board allows for a 0 to a maximum of 10 volt ramp at the comparator input. All AEC signals must fit within this range (for all film/screens, densities, and techniques).
- Most x-ray applications require the use of two or more different film screen combinations, all of which will require different exposure doses.
- Using the slowest film screen combination, the required film input dose will be determined.
- Once this value is determined (during AEC calibration) the density calibration is performed to allow 100% (double the dose) and 50% (half the dose) values. These are typical values and will determine the maximum required range of the AEC reference voltage (output from the D/A converter).
- Figure 3D-4 illustrates the different windows required for various film screen combinations.

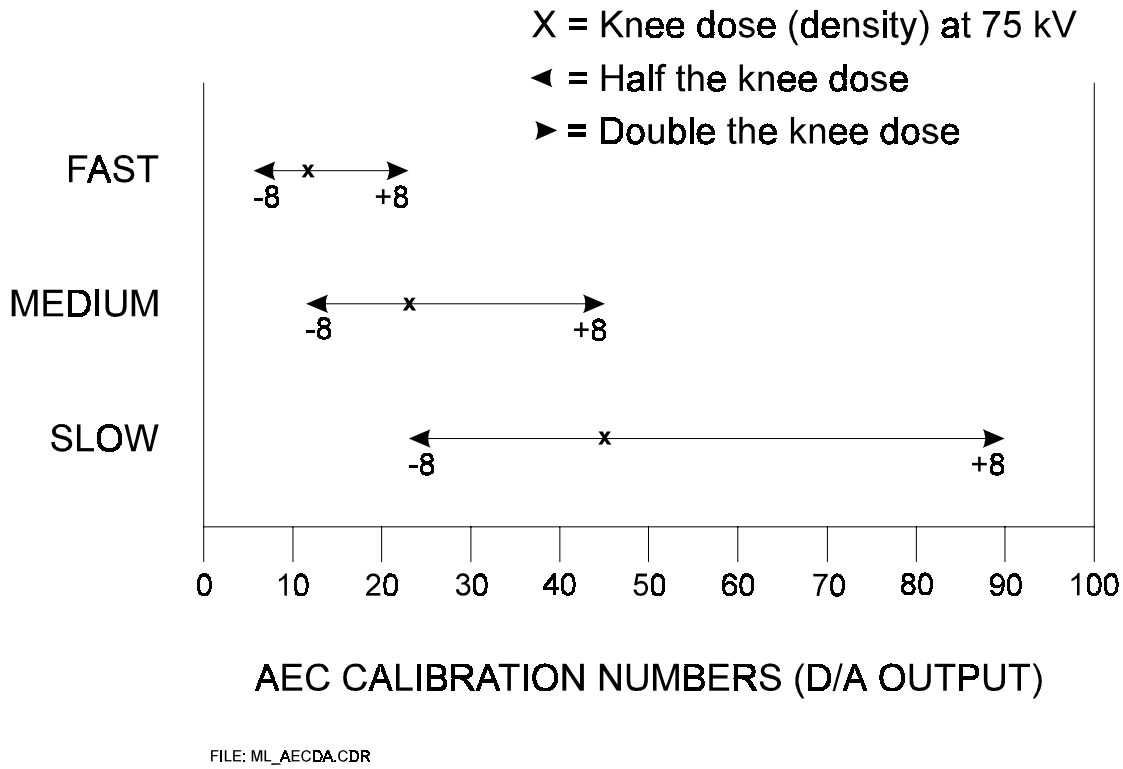


Figure 3D-4: Film/screen speed vs. D/A output

3D.1.6 Multiple Spot Compensation

Separate density compensation is provided when a SFD (Spot Film Device) is used for multiple film splits. This allows compensation when the SFD diaphragm is in the X-ray field.

An external output from the SFD must be provided when multiple spots are requested to enable this function.

3D.1.7 A Typical R&F Room

Figure 3D-5 below shows source-image distances and image receptors as used in a typical R&F installation.

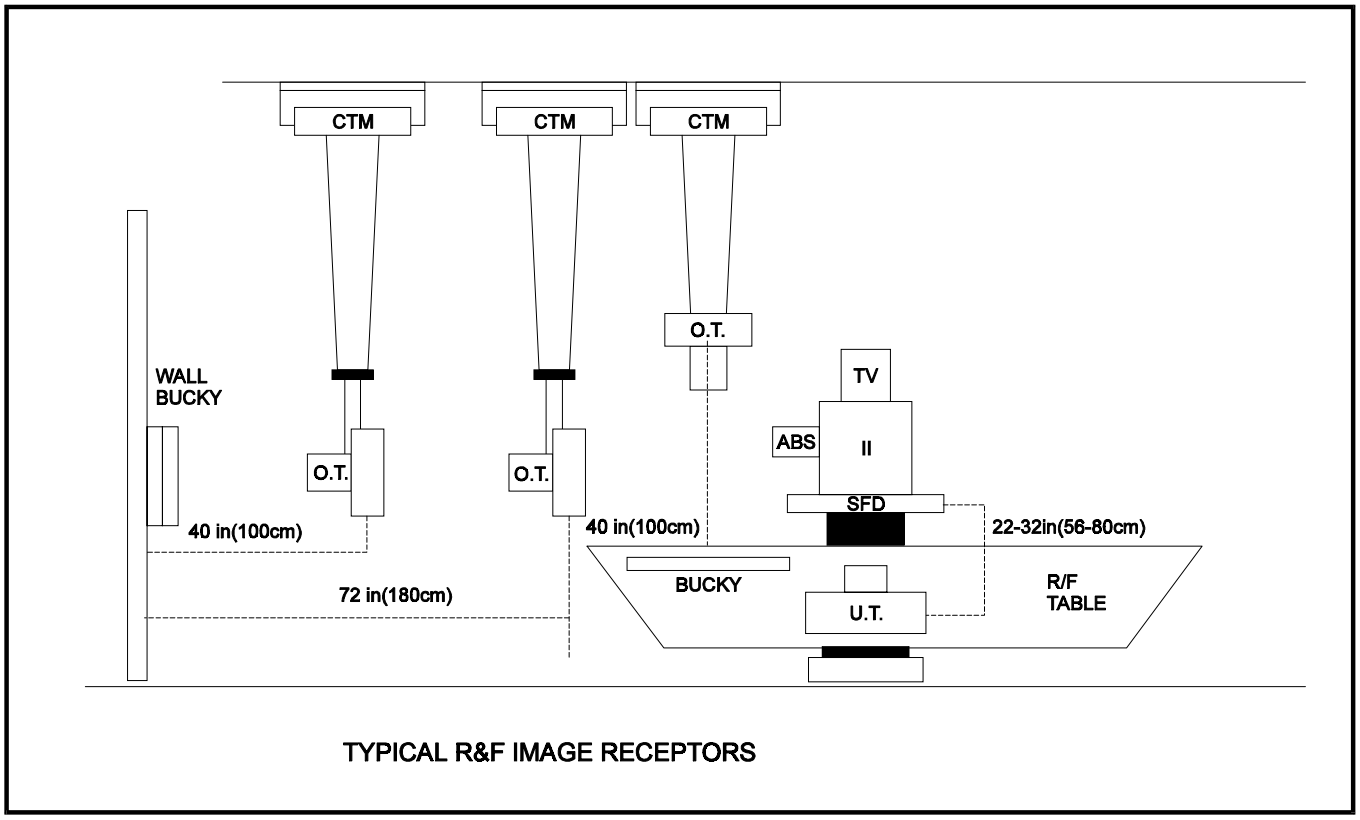


Figure 3D-5: Typical R&F installation

3D.2.0 PRECALIBRATION SETUP

3D.2.1 AEC Setup Worksheet

Before continuing, it is suggested that a copy of the table below be filled in with all required information. Refer to the example AEC setup worksheet on the next page.

FUNCTION		RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4
Film/Screen	1.				
	2.				
	3.				
Nominal optical density:					
Grid ratio/SID:					
Min - max kVp range:					
± Density steps ✻					
Density dose change (per step) ✻	+%:				
	-%:				
Chamber type:					
Regulatory AEC dose requirements?					
Is film processing maintained?					
Assigned receptor name:					
Are all cassettes similar?					
Additional notes:					
Additional notes:					

Table 3D-1: AEC setup worksheet

ALL RECEPTORS MUST HAVE THE SAME NUMBER OF DENSITY STEPS AND THE SAME DENSITY DOSE CHANGE PER STEP (DENSITY SETTINGS ARE COMMON TO ALL FILM SCREENS AND RECEPTORS).

3D.2.1 AEC Setup Worksheet (Cont)

Note: ***The example below is supplied for reference only. It does not represent an actual installation.***

FUNCTION		RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4
Film/Screen	1.	Lanex/reg	Lanex/reg	Lanex/reg	PMT/I.I.
	2.	Lanex/med	Lanex/chest		
	3.				
Nominal optical density:		1.2	1.1	1.4	
Grid ratio/SID:		12:1	8:1	10:1	10:1
Min - max kVp range:		60 - 120	65 - 140	80 - 110	70 - 120
± Density steps		±8	±8	±8	±8
Density dose change	+%:	12.5	12.5	12.5	12.5
(per step)	-%:	6.25	6.25	6.25	6.25
Chamber type:		Ion	Solid state	Ion	PMT
Regulatory AEC dose requirements?		Yes	Yes	Yes	Yes
Is film processing maintained?		Yes	Yes	Yes	Yes
Assigned receptor name:		Table	Wall	SFD	Digital
Are all cassettes similar?		Yes	Yes	Yes	N/A
Additional notes:					
Additional notes:					

Table 3D-2: Sample AEC setup worksheet

3D.2.2 AEC Precalibration Checks

It is recommended that a copy of the form below be filled in with the required information before attempting AEC calibration.

1.	Verify that the AEC chambers are mounted correctly in the bucky or spot film device. Note that some chamber types must be physically isolated from equipment ground, refer to figure 3D-6 as an example.	CHECK √:
2.	Verify that each AEC chamber/pickup is properly connected to its intended input channel on the AEC board. ***Refer to AEC board pictorials, figure 3D-8 to 3D-10 for input channel designations***	CHECK √:
3.	Make and type of AEC chamber/pickup:	AEC Ch 1_____ AEC Ch 2_____ AEC Ch 3_____ AEC Ch 4_____
4.	Verify signal grounding for the AEC chamber. The only electrical ground should be at the AEC board in the generator. This applies to the ground braid (shield) for the AEC signal cable and to the ground return conductor(s) in the AEC signal cable.	CHECK √:
5.	Verify that the AEC board is fully inserted into the mating edge connector (if applicable), that all connections to the AEC board are secure, and that the AEC board is properly fastened to the door support panel.	CHECK √:
6.	Before calibrating, verify that the AEC system is functioning. This includes the AEC chambers/devices and the AEC circuits in the generator. Each of the fields on the AEC device must be able to terminate the exposure.	CHECK √:
7.	Radiographic techniques to be performed with the equipment (high kV chest, G.I. studies etc)?	
8.	Normal exposure factors used by the customer (typical mAs/kV range)?	

Table 3D-3: Precalibration checklist

3D.2.3 AEC Chamber Installation

Figure 3D-6 shows an installed AEC chamber. Note particularly the use of a suitable insulating material to isolate the body of the chamber from the receptor ground. This is required for non-insulated AEC chambers.

3D.2.3 AEC Chamber Installation (Cont)

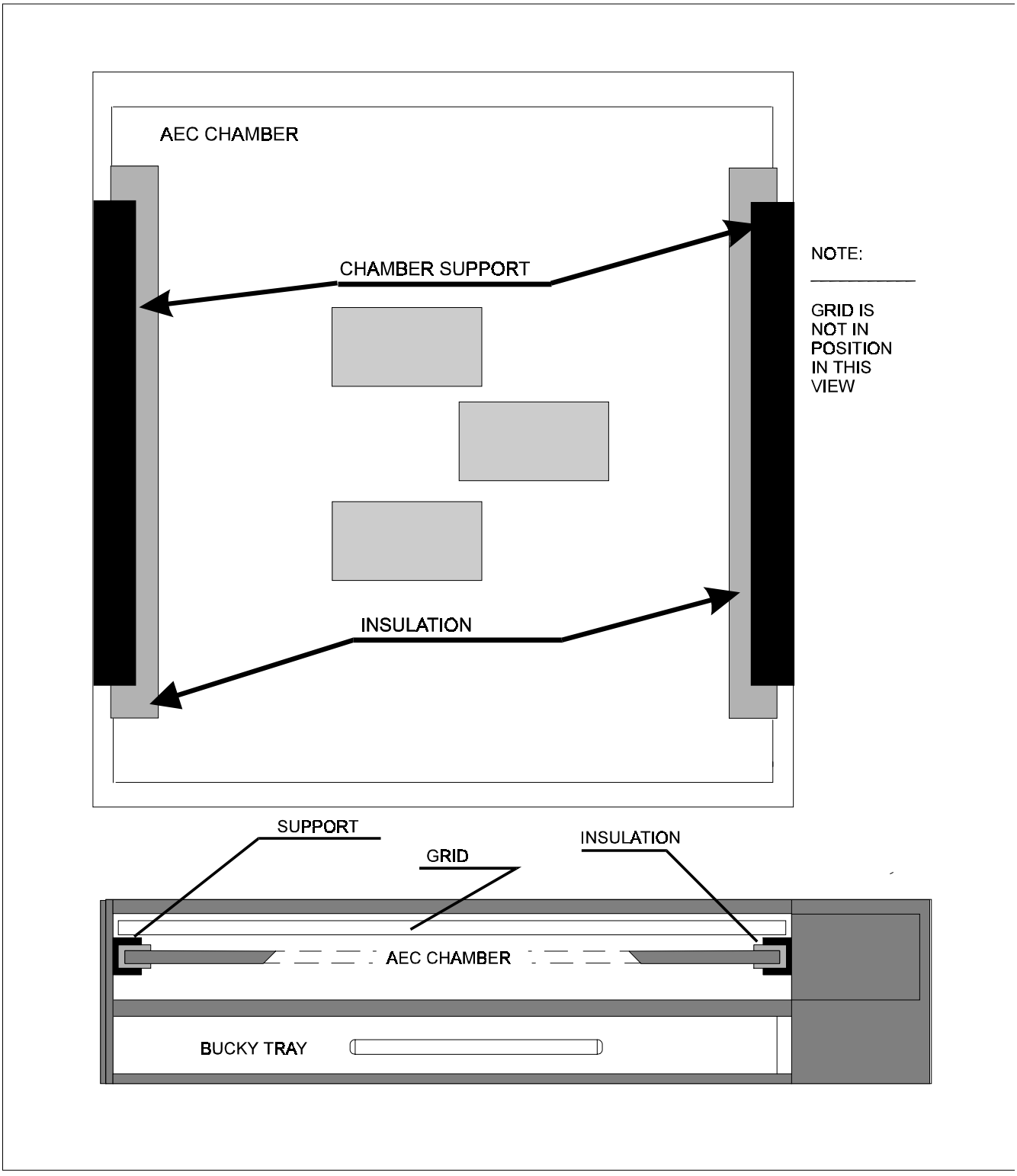


Figure 3D-6: AEC chamber installation

3D.2.4 AEC Pickup Connections (Overview)

Review the applicable sections of chapter 3 section B and C for interfacing AEC devices and programming the image receptors to select the correct AEC device (or no AEC if desired). It should be ensured that each receptor used for AEC has a bucky or equivalent. A typical R&F room configuration will consist of the following:

- Table bucky
- Wall bucky
- Spot film bucky
- Aux - digital acquisition

Refer to Figure 3D-7 for typical AEC connections. This is a simplified view only, refer to figures 3D-8 to 3D-11 for AEC board layouts used in Millenia and Indico 100 generators. Refer to chapter 1E for the AEC board location in your generator.

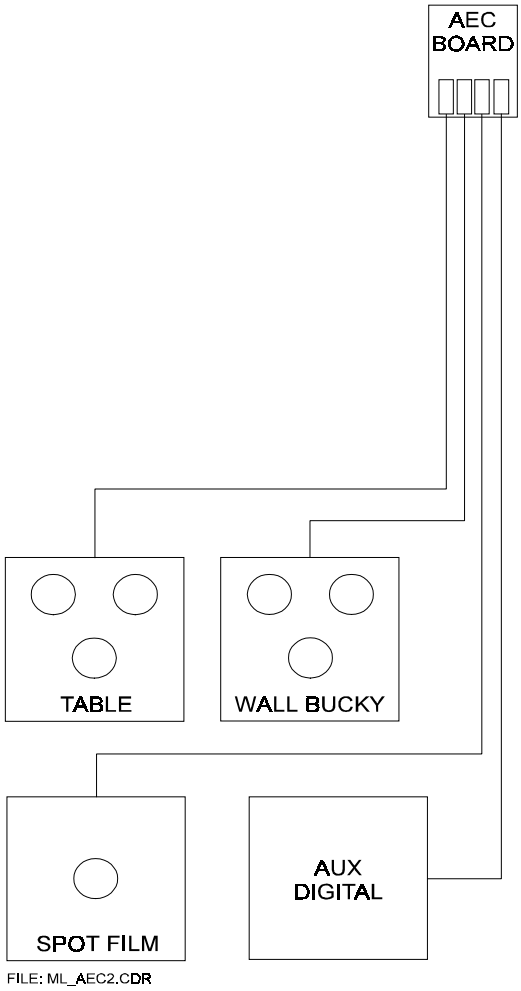


Figure 3D-7: AEC pickup connections

3D.2.5 AEC Board (Solid State Chambers)

The AEC board shown below is compatible with various makes/models of solid state chambers (i.e. Comet, Ziehm, Gilardoni). This AEC board is used in various models of generators requiring those AEC chamber types.

This board will be fitted with 6 pin circular connectors (J1 to J4) or with 5 pin in-line connectors (J11 to J14), depending on the application.

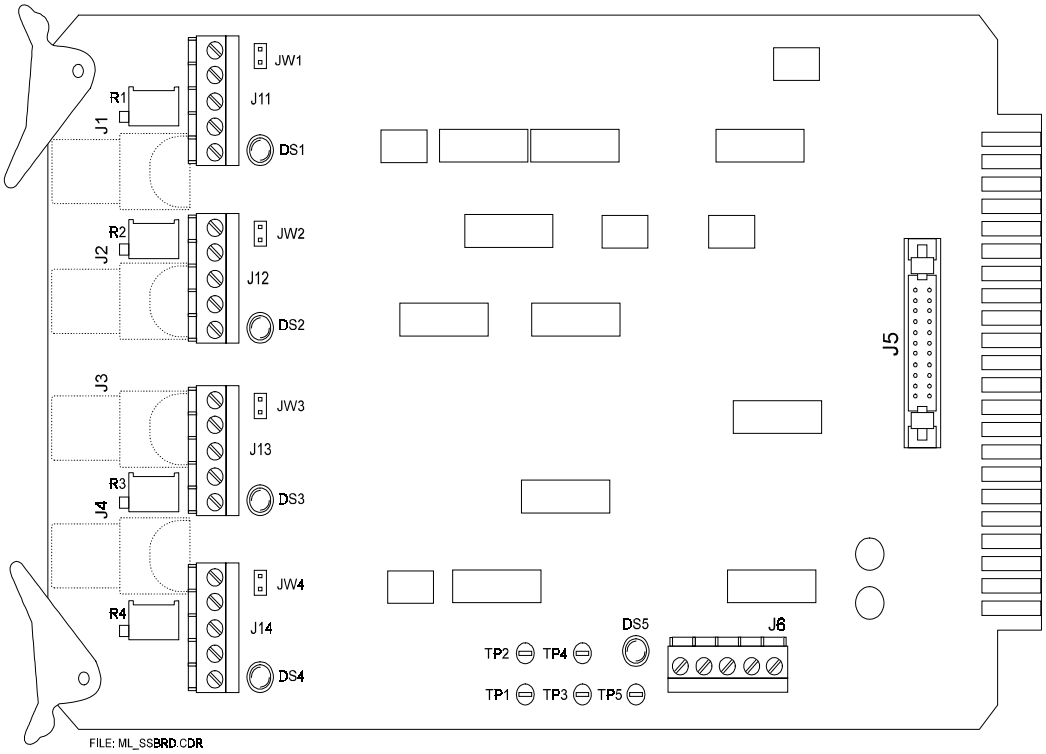


Figure 3D-8: Dedicated solid state AEC board

AEC board input assignment:

- Ch 1 = J1/J11 - Table Radiographic Bucky.
- Ch 2 = J2/J12 - Vertical Wall Bucky.
- Ch 3 = J3/J13 - Spot Film Device
- Ch 4 = J4/J14 - Aux. (Extra Bucky, Digital Acquisition, etc.)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

3D.2.5 AEC Board (Solid State Chambers) Cont

The following tables show the pinouts for both the 6 pin circular connectors and for the 5 pin in-line connectors on the AEC board in figure 3D-8.

FUNCTION	PIN	
Anode	1	NOTE: PINS 1, 2, AND 3 ON THE
Anode	2	CIRCULAR CONNECTOR ARE
Anode	3	ALL CONNECTED IN PARALLEL.
Cathode, left	4	
Cathode, right	5	
Cathode, middle	6	
Ground	Connector shell	

Table 3D-4: Pinouts for 6 pin circular connector

FUNCTION	PIN
Anode	2
Cathode, left	3
Cathode, right	5
Cathode, middle	4
Ground	1

Table 3D-5: Pinouts for 5 pin in-line connector

If the AEC input signal has excessive electrical noise superimposed on the signal, it is suggested that jumpers JW1 to JW4 as appropriate be temporarily installed. If this improves the signal to noise ratio, the jumper(s) should be left in. Excessive signal to noise ratio generally shows up as inconsistent AEC exposure times at low mAs values.

It is the responsibility of the installer to determine the need for these jumper(s).

3D.2.6 AEC Board (Ion Chambers)

The AEC board shown below is compatible with various makes/models of ion chambers (i.e. AID, GE, Vacutec, Philips Amplimat). This AEC board is used in various models of generators requiring those AEC chamber types and requiring short AEC time compensation.

This board will be fitted with 15 pin D connectors (J11 to J14) or with 12 pin in-line connectors (J1 to J4), depending on the application.

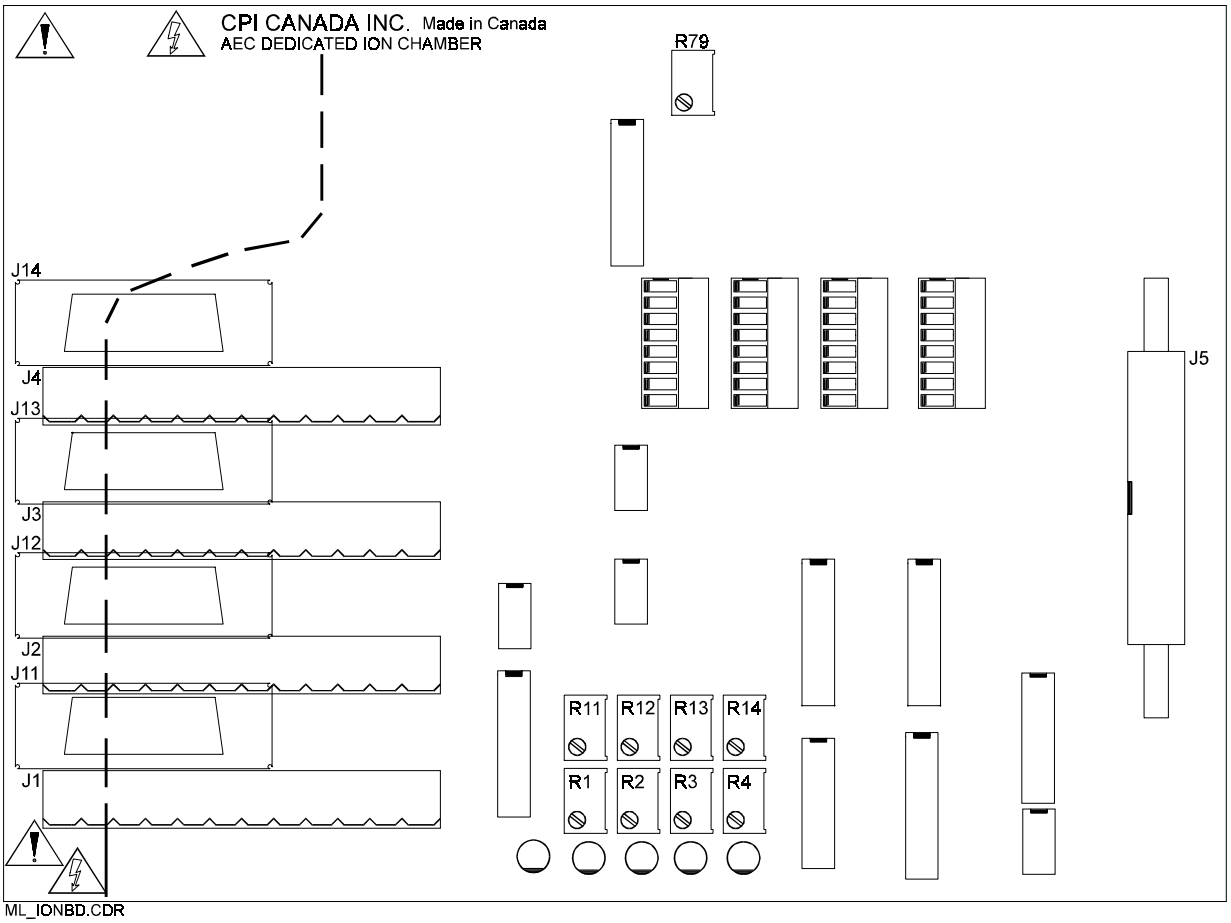


Figure 3D-9: Dedicated ion chamber AEC board

AEC board input assignment:

- Ch 1 = J1/J11 - Table Radiographic Bucky.
- Ch 2 = J2/J12 - Vertical Wall Bucky.
- Ch 3 = J3/J13 - Spot Film Device
- Ch 4 = J4/J14 - Aux. (Extra Bucky, Digital Acquisition, etc.)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

3D.2.6 AEC Board (Ion Chambers) Cont

The following potentiometers are used for short AEC exposure time compensation:

- R11 is used for channel 1 short exposure time compensation.
- R12 is used for channel 2 short exposure time compensation.
- R13 is used for channel 3 short exposure time compensation.
- R14 is used for channel 4 short exposure time compensation.

R79 adjusts the output of the high voltage bias supply. This is only fitted on versions of this board intended for use with ion chambers which require a separate high voltage bias supply. R79 adjusts the value of the +300 and/or the +500 and the +45 VDC outputs, and should be set as per the ion chamber manufacturer specifications.

The following tables show the pinouts for both the 15 pin D connectors and for the 12 pin in-line connectors on the AEC board in figure 3D-9.

FUNCTION	PIN	NOTE
+300 ***or*** +500 VDC output	1	+500 and/or +300, and +45 VDC outputs are provided on configurations of this board
Not used	2	designed to interface to ion chambers requiring
Right field select	3	these voltage outputs only. Pin 1 will be wired
Start command output	4	to supply +300 VDC ***OR*** +500 VDC, as per the
+45 VDC output	5	AEC chanber requirements.
-24 VDC output	6	
Signal input	7	
Ground	8	
Not used	9	
Not used	10	
Left field select	11	
Middle field select	12	
Ground	13	
+12 VDC output	14	
-12 VDC output	15	

Table 3D-6: Pinouts for 15 pin D connector

FUNCTION	PIN	NOTE
+500 VDC output	1	+500, +300, +45 VDC outputs are provided on configurations of this board designed to interface to ion chambers requiring these voltage outputs only. +12, -12, -24 VDC outputs are typically used as the DC supply for a pre-amplifier, often part of the ion chamber.
+300 VDC output	2	
+45 VDC output	3	
+12 VDC output	4	
-12 VDC output	5	
-24 VDC output	6	
Ground	7	
Start command output	8	
Left field select	9	
Middle field select	10	
Right field select	11	
Signal input	12	

Table 3D-7: Pinouts for 12 pin in-line connector

3D.2.7 AEC Board (Universal AEC Board)

The AEC board shown below is factory configured to be compatible with most makes/models of AEC chambers (ion and solid state) on the market. This assembly also contains a low current, high voltage supply for a photomultiplier tube (PMT). The PMT supply is located on the upper board, which also contains the connectors to interface to the AEC pickup device(s).

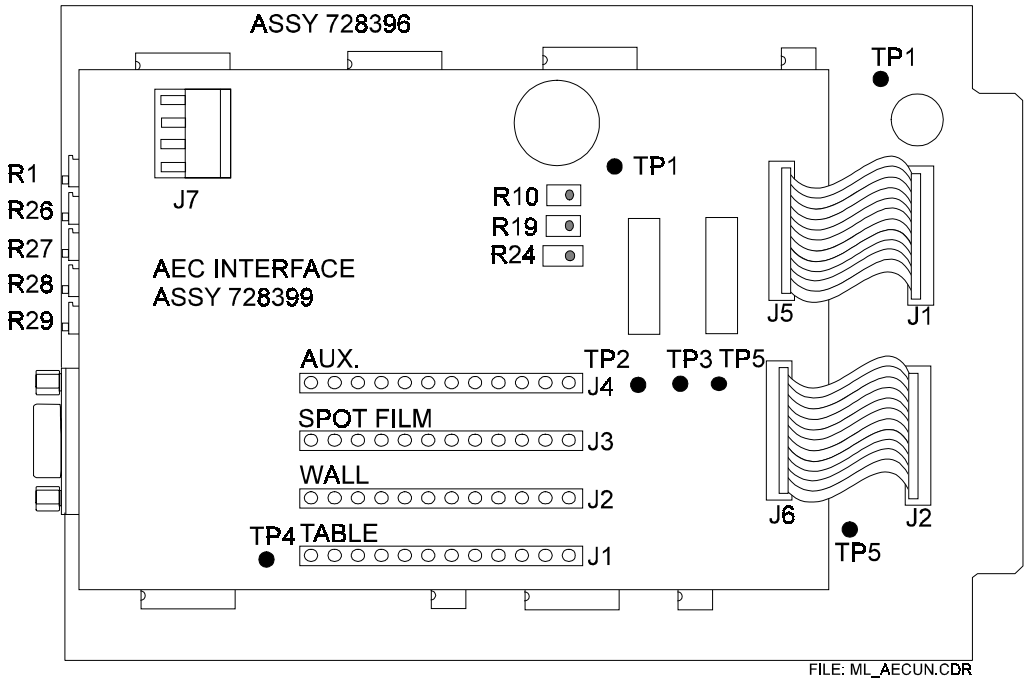


Figure 3D-10: Universal AEC board

AEC board input/output assignment:

- Ch 1 = J1 - Table Radiographic Bucky.
- Ch 2 = J2 - Vertical Wall Bucky.
- Ch 3 = J3 - Spot Film Device.
- Ch 4 = J4 - Aux. (Extra Bucky, Digital Acquisition, etc.).
    - J7 = High voltage output for the PMT (if used)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R26 is used for channel 2 gain adjustment.
- R27 is used for channel 3 gain adjustment.
- R28 is used for channel 4 gain adjustment.

Refer to the end of subsection 3D.2.7 for the procedure for adjusting R10, R19, and R24.

3D.2.7 AEC Board (Universal AEC Board) Cont

The following table shows the pinouts for the 12 pin connectors J1 to J4 on the AEC board in figure 3D-10 and 3D-11. The pins on J7 are all connected in parallel, thus the PMT high voltage may be taken from any of the pins on that connector.

The connections to the AEC pickup chamber vary considerably between ion chambers and solid state chambers. For clarity two tables are shown below, the first for ion chambers and the second for solid state chambers.

FUNCTION	PIN	NOTE
+500 VDC output	1	+500, +300, +50 VDC outputs provided for ion chamber use if required. +12, -12, -24 VDC outputs are typically used as the DC supply for a pre-amplifier, often part of the ion chamber. The start command, and left, middle, right field select outputs are jumper configured to be active high or active low as per the AEC chamber requirements. The signal input is jumper configured to accept a positive going or negative going ramp or DC signal as per the AEC chamber output.
+300 VDC output	2	
+50 VDC output	3	
+12 VDC output	4	
-12 VDC output	5	
-24 VDC output	6	
Ground	7	
Start command output	8	
Left field select	9	
Middle field select	10	
Right field select	11	
Signal input	12	

Table 3D-8: Ion chamber connections

FUNCTION	PIN	NOTE
+500 VDC output	1	Not used for solid state AEC chambers
+300 VDC output	2	Not used for solid state AEC chambers
+50 VDC output	3	Not used for solid state AEC chambers
+12 VDC output	4	Not used for solid state AEC chambers
-12 VDC output	5	Not used for solid state AEC chambers
-24 VDC output	6	Not used for solid state AEC chambers
Ground	7	Connect pin 8 to pin 7 (ground). Connect the common anodes for left, middle, right to pin 8. Connect cathode (left) to *LEFT*, cathode middle to *MIDDLE*, and cathode right to *RIGHT*. Cable shield (if used) connects to pin 8.
Start	8	
Left	9	
Middle	10	
Right	11	
Signal input	12	Not used for solid state AEC chambers

Table 3D-9: Solid state chamber connections

3D.2.7 AEC Board (Universal AEC Board) Cont

R10, R19 and R24 adjust the output voltage from the high voltage power supply on the AEC interface board (the upper board on the universal AEC board assembly in figure 3D-10 and 3D-11). This high voltage supply generates the PMT high voltage, up to approximately -1000 VDC available at J7, and also the nominal +500, +300 and +50 VDC supplies noted in table 3D-8. The +500, +300 and +50 VDC supplies are available to bias ion chambers if needed and are adjustable as defined below.

These potentiometers are switched into the circuit electronically by logic circuits connected to the AEC channel select commands. Only one potentiometer will be active at any given time, the condition under which each potentiometer is active is described below, along with the function of that potentiometer.

- R10 adjusts the high voltage supply output for the PMT when ABS operation is selected. This is described in chapter 3E.
- R24 adjusts the high voltage supply output when AEC channel 1, 2, or 3 is selected. AEC channels 1, 2, 3 are normally used with an AEC chamber.

  R24 will be used to adjust the +500, +300 and +50 VDC bias voltage outputs if required for ion chamber(s) connected to AEC channels 1, 2 or 3.
- R19 adjusts the high voltage supply output when AEC channel 4 is selected. AEC channel 4 is normally used for digital acquisition or spot film work using a PMT pickup for AEC control. This will typically be the same PMT used for ABS control during fluoroscopy operation.

Refer to 3D.2.9 for further details if using a PMT for AEC control on AEC channel 4.

3D.2.8 AEC Board (Universal AEC Board With Short AEC Time Compensation)

The AEC board shown below has short AEC time compensation, and is factory configured to be compatible with most makes/models of AEC chambers (ion and solid state) on the market. This assembly also contains a low current, high voltage supply for a photomultiplier tube (PMT). The PMT supply is located on the upper board, which also contains the connectors to interface to the AEC pickup device(s).

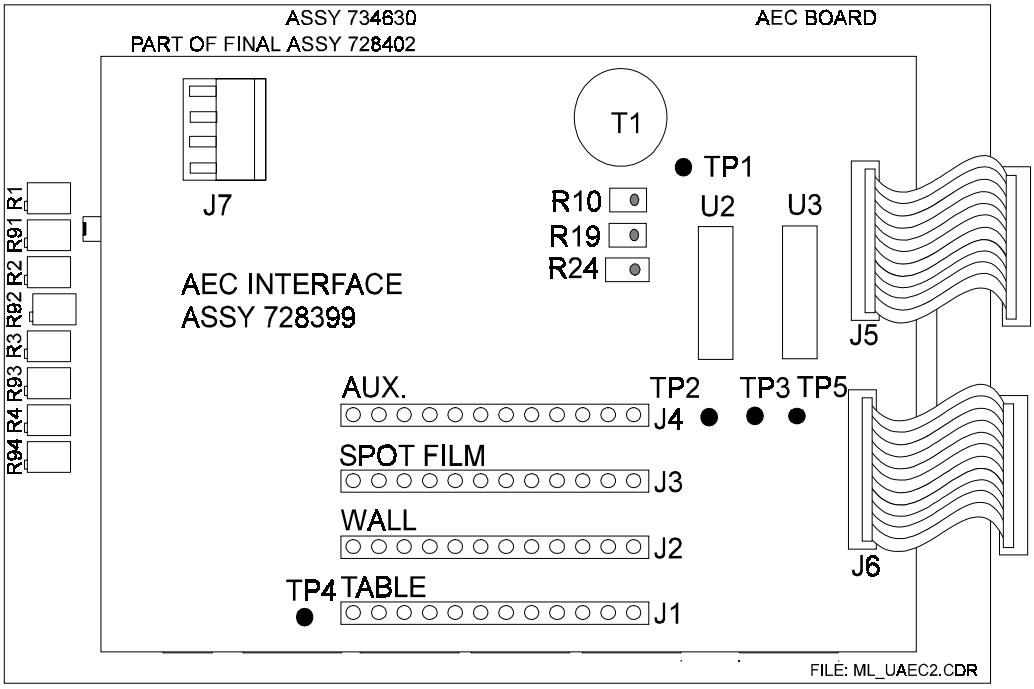


Figure 3D-11: Universal AEC board with short AEC time compensation

3D.2.8 AEC Board (Universal AEC Board With Short AEC Time Compensation) Cont

In order to clearly show the adjustment pots on the lower (AEC) board, the upper board which contains the AEC and PMT interface connectors and the high voltage supply is shown shifted from its actual position.

AEC board input/output assignment:

- Ch 1 = J1 - Table Radiographic Bucky.
- Ch 2 = J2 - Vertical Wall Bucky.
- Ch 3 = J3 - Spot Film Device.
- Ch 4 = J4 - Aux. (Extra Bucky, Digital Acquisition, etc.).
- J7 = High voltage output for the PMT (if used)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

The following potentiometers are used for short AEC exposure time compensation:

- R91 is used for channel 1 short exposure time compensation.
- R92 is used for channel 2 short exposure time compensation.
- R93 is used for channel 3 short exposure time compensation.
- R94 is used for channel 4 short exposure time compensation.

Refer to tables 3D-8 and 3D-9 for the connector pinouts. Refer to the end of subsection 3D.2.7 for the procedure for adjusting R10, R19, and R24.

3D.2.9 AEC Using A PMT

WARNING: ***SWITCH OFF THE GENERATOR BEFORE CONNECTING A PMT, AND USE APPROPRIATE HIGH VOLTAGE PRECAUTIONS WHEN MEASURING THE PMT HIGH VOLTAGE.***

The following applies if a PMT is to be used for AEC control on channel 4 as described above. It is suggested that the AEC calibration on AEC channels 1, 2, and 3 as applicable be done first (sections 3D.5.0 to 3D.11.0) before calibrating AEC channel 4.

Step	Action
1.	Route the output signal from the PMT to AEC input channel 4 as per figure 3D-12. The resistor divider network will need to be provided by the installer. Appropriate high voltage shielded cable should be used for the PMT signal connections.
2.	Set the PMT voltage to approximately -650 VDC for AEC operation using R19 on the AEC interface board. Note that AEC channel 4 must be selected in order for R19 to be made active. ***USE TP5 ONLY ON THE AEC INTERFACE BOARD (FIGURE 3D-10, 3D-11) FOR THE HV METER GROUND WHEN MEASURING PMT HIGH VOLTAGE. CONNECT THE GROUND LEAD FIRST BEFORE MEASURING THE HIGH VOLTAGE.*** **DO NOT ATTEMPT TO MEASURE THIS WITHOUT A SUITABLE METER.**
3.	Follow the procedure in section 3D.5.0 steps 6 to 14. In the **AEC SETUP** menu, select **ION** chamber, **FILM SCREEN 1** only, and **CENTER FIELD** only.
4.	Enter the calibration value **45** into EACH of the kV breakpoints. The procedure is detailed in step 16 of 3D.5.0 for the 75 kV knee breakpoint. The remaining breakpoints are set in a similar manner (refer to the balance of 3D.5.0 for details on accessing those breakpoint settings).
5.	Adjust R28 on the AEC board for the desired I.I. input exposure dose.
6.	The PMT voltage that was set in step 2 may need to be adjusted up or down if R28 does not provide the desired adjustment range in step 5.

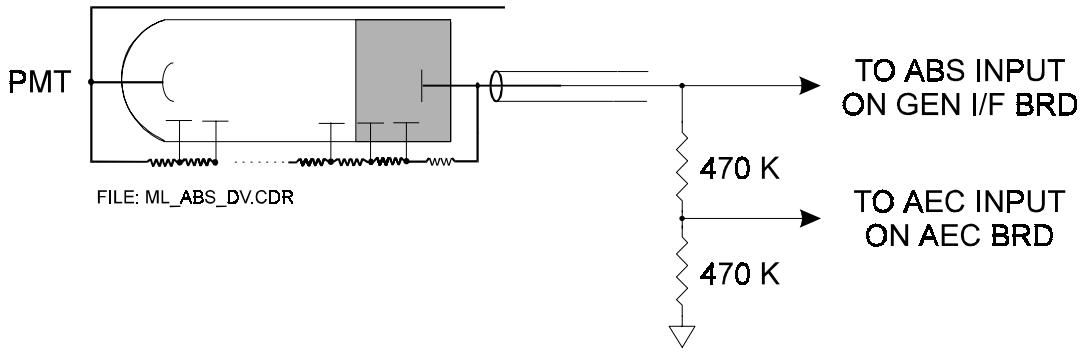


Figure 3D-12: Connections for PMT AEC

3D.3.0 PRECALIBRATION NOTES:

This section contains information that must be understood and confirmed prior to and/or during AEC calibration.

CAUTION: ***THE PROCEDURES IN THESE SECTIONS REQUIRE X-RAY EXPOSURES. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

SHOULD AN IMPROPER TECHNIQUE BE SELECTED, OR AN AEC FAULT OCCUR CAUSING NO AEC FEEDBACK SIGNAL TO THE GENERATOR, THE EXPOSURE WILL TERMINATE IF THE RAMP VOLTAGE FAILS TO REACH 4% OF THE EXPECTED RAMP VOLTAGE WHEN THE EXPOSURE TIME REACHES 20% OF THE SELECTED B.U.T. (B.U.T. = BACK UP TIME).

- When using PMTs or photo diodes for AEC from the output of an image intensifier, there is normally no need to iterate all the kV break points. It is usually sufficient to use the 75 kV breakpoint calibration value for that film screen at all kV breakpoints. If doing this, the calibration values should be confirmed using the acquired digital images at all kV breakpoints.
- During calibration, all AEC exposures should be done using mA values such that the exposures are in the 30 to 100 ms range UNLESS STATED OTHERWISE.
- During AEC calibration, always ensure that the central ray is centered relative to the image receptor.
- Prior to placing the absorbers, ensure that the collimator is opened sufficiently to cover ALL fields on the AEC pickup device.
- Ensure that the absorber is positioned such as to fully cover the X-ray field. The absorber must extend a minimum of 3/8″ (10 mm) beyond the X-ray field.
- All components/assemblies used during AEC calibration must be those which will be used during procedures, and must be positioned as they will be in actual use of the X-ray room.
- The generator must be known to be calibrated before proceeding.
- During AEC calibration, if exposure times do not change if the mA is varied, it may be that the input signal level to the AEC board may be too high. If this is experienced, check the ramp voltage at the output of the first gain stage (the first operational amplifier output) on the AEC board for the subject AEC channel. This voltage must never exceed 10 V. If this voltage **does** exceed 10 V, reduce the input signal level as required.

3D.4.0 ABSORBER EQUIVALENTS

The following calibration procedure details the use of copper absorbers. Water or aluminum may be used as an absorber instead of copper if required. Table 3E-1 in chapter 3E (ABS calibration) lists water and aluminum equivalents of selected copper thickness.

3D.5.0 AEC CALIBRATION (TABLE BUCKY)

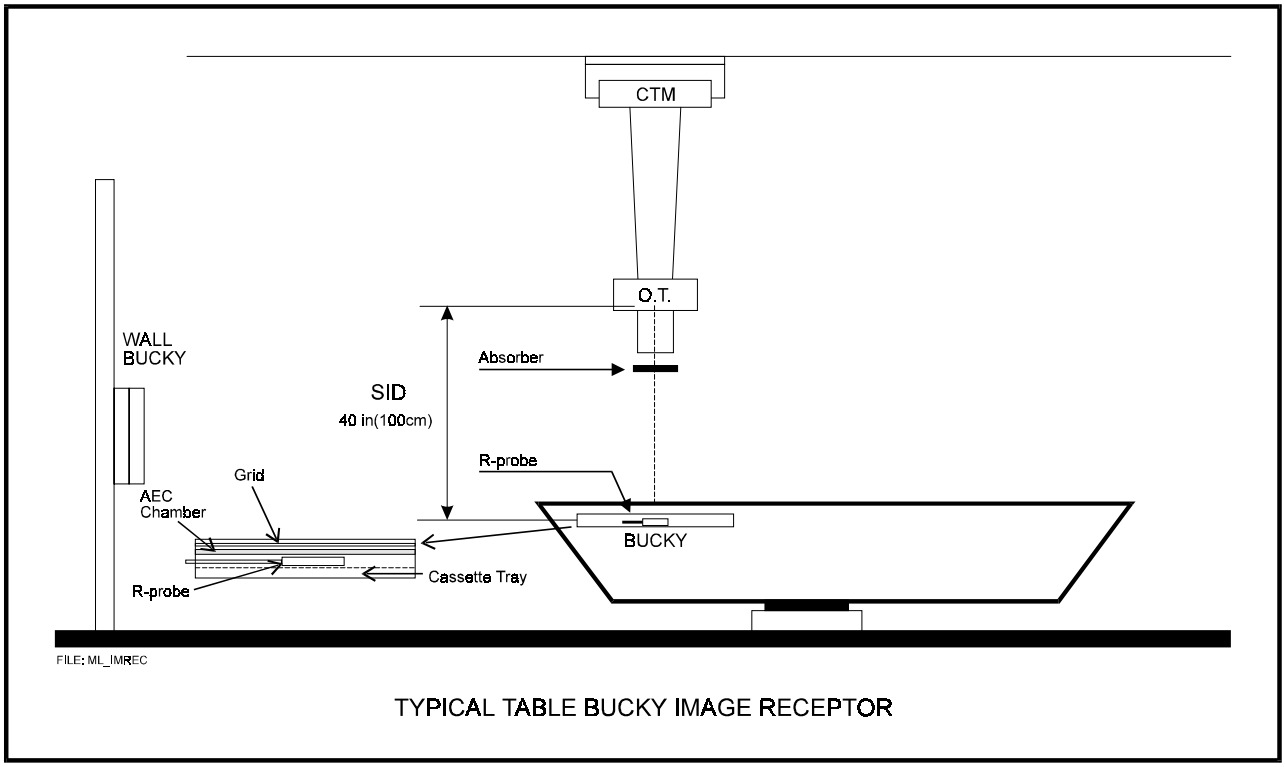


Figure 3D-13: Equipment setup for table bucky AEC calibration

Step	Action
	SETUP FOR AEC CALIBRATION
IF THE AEC BOARD BEING CALIBRATED HAS SHORT AEC TIME COMPENSATION (FIGURE 3D-9 OR 3D-11), THE SHORT EXPOSURE TIME COMPENSATION MUST FIRST BE DISABLED. **TO DO THIS, ADJUST ALL SHORT AEC EXPOSURE TIME COMPENSATION POTENTIOMETERS TO ZERO, IE SUCH THAT THE WIPERS ON EACH POT ARE GROUNDED. VERIFY THE CORRECT SETTINGS BY USING AN OHMETER ON LOW OHMS RANGE AND ENSURING A NEAR ZERO OHMS READING FROM THE WIPER OF EACH SHORT AEC TIME COMPENSATION POT TO GROUND. REFER TO TABLE 3D-11 FOR THE SHORT AEC TIME COMPENSATION POTENTIOMETER DESIGNATIONS**. **FAILURE TO PRESET THESE POTS WILL RESULT IN DIFFICULTY IN PERFORMING AEC CALIBRATION.**	
1.	Set up the X-ray tube stand as shown in figure 3D-13.
2.	Align the tube stand and table bucky such that the central ray is centered relative to the image receptor.
3.	Open up the collimator to expose all three fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4.	Place the R probe at the film plane, i.e. behind the grid. If this cannot be done, then place the probe on the table top. Ensure that the R-probe is located as close as possible to the central ray, but not blocking any pickup areas on the AEC device. The R meter must be set to measure in the micro-R range.

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

Step	Action
5.	Place 1.5 mm of copper (pure grade) in front of the collimator, ensuring that the radiation is COMPLETELY blocked by the absorber.
6.	Place the generator into the programming mode. Refer to section 3C.1.1.
7.	From the **GENERATOR SETUP** menu select **GEN CONFIGURATION.**
8.	From the **GEN CONFIGURATION** menu select **AEC SETUP.**
9.	Set up the AEC parameters in the **AEC SETUP** menu *FOR EACH ACTIVE AEC CHANNEL*. Refer to section 3C.5.5 for definitions of the items in the **AEC SETUP** menu.
10.	Set up the image receptors in the **RECEPTOR SETUP** menu such that each receptor has the desired AEC channel assigned to it. Refer to section 3C.5.3 for **RECEPTOR SETUP** information.
11.	In the **RECEPTOR SETUP** menu, set **MEMORY** to **NO** for each image receptor. This will ensure that the next receptor being calibrated will not remember the techniques from the previous receptor. The **MEMORY** function may be reset as desired after AEC calibration is completed.
12.	In the **RECEPTOR SETUP** menu, ensure that the **AEC BACKUP MAS** and **AEC BACKUP MS** are set sufficiently high that the generator backup timer will not terminate the exposure.
13.	From the **GEN CONFIGURATION** menu select **AEC CALIBRATION.**
14.	From the **AEC CALIBRATION** menu select **FILM SCREEN 1** (the slowest film screen combination).

CAUTION: ***DURING THE FOLLOWING CALIBRATION PROCEDURE, BE SURE THAT THE SELECTED TECHNIQUES WILL NOT OVERLOAD THE X-RAY TUBE. USE CAUTION WHEN REPEATING EXPOSURES AS THIS MAY QUICKLY OVERLOAD THE X-RAY TUBE. MOST X-RAY TUBE MANUFACTURERS RECOMMEND NO MORE THAN TWO HIGH SPEED STARTS PER MINUTE.***

NOTE: ***BE SURE TO USE THE SAME CASSETTE FOR EACH EXPOSURE AT THAT FILM SPEED.***

AEC BOARD	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4
Solid State (Fig 3D-8)	R1	R2	R3	R4
Ion Chamber (Fig 3D-9)	R1	R2	R3	R4
Universal (Fig 3D-10)	R1	R26	R27	R28
Universal (Fig 3D-11)	R1	R2	R3	R4

Table 3D-10: AEC board gain pot designations

AEC BOARD	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4
Ion Chamber (Fig 3D-9)	R11	R12	R13	R14
Universal (Fig 3D-11)	R91	R92	R93	R94

Table 3D-11: Short AEC time compensation pot designations

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

The following screens are used for AEC calibration

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                        DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3


      EXIT
```

```
*TUBE?      0%HU        AEC CAL, F/S 1*
50KV:  84.0:                                        85KV:  42.8
55KV:  78.0:                                        95KV:  38.0
65KV:  66.0:                                                +
75KV:  54.0                                                 -
3200MS   <<                                          >>
```

```
*TUBE?      0%HU        AEC CAL, F/S 1*
110KV:  34.0:
130KV:  28.0:
RLF COMPENSATION                                            +
MULT. SPOT  COMP:        0%                                 -
3200MS   <<
```

Step	Action
	75 KV KNEE BREAKPOINT CALIBRATION:
15.	Select the table bucky image receptor.
16.	Select the **75 kV** knee breakpoint and enter the value **45** using the **+** or **-** buttons adjacent to the LCD display.
17.	Select the appropriate mA for the first film speed being calibrated per table 3D-13, *remembering that the slowest film screen used in that installation must be calibrated first* (example 320 mA for 100 speed film). Select large focus, center field.
18.	Make an exposure and note the dose and mAs.
19.	Referring to table 3D-12, select the estimated dose required for the film speed being calibrated i.e. 1025 ± 25 µR (see note on next page regarding conversion of µR to µGy if desired) at the 75 kV knee breakpoint for 100 speed film. **Note that the dose values in the table are based on the R-probe being located at the film plane. If the probe was placed in front of the grid the dose values shown in the tables must be increased accordingly. The dose in front of the grid will typically be approximately double the dose at the film plane.**
20.	Adjust the required gain potentiometer on the AEC board (see note below) while taking exposures until the dose noted in the previous step is obtained. • **CHANNEL 1 ON THE AEC BOARD IS TYPICALLY USED FOR THE TABLE BUCKY AEC CHAMBER. YOUR INSTALLATION <u>MAY</u> USE A DIFFERENT CHANNEL ON THE AEC BOARD.** • **REFER TO TABLE 3D-10 FOR THE AEC BOARD GAIN POTENTIOMETER (GAIN POT) DESIGNATIONS FOR THE VARIOUS AEC BOARDS.**

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

FILM SPEED	FILM PLANE DOSE @ 75 kV
100	1025 ± 25 uR
200	550 ± 25 uR
400	260 ± 12 uR
800	135 ± 12 uR

Table 3D-12: Estimated knee dose vs film speed @ 75 kV

These are TYPICAL dose inputs to the film cassette plane at an SID of 40″(100mm), using a grid with a 12:1 ratio.

NOTE: ***To convert from µR to µGy divide the value in µR by 100. This will give the value in µGy (for example 100 µR = 1 µGy.***

Step	Action
21.	Load a test cassette with fresh film and install it in the image receptor. Using the same technique as in the previous step, expose the film and develop it.
22.	Measure the optical density. The desired value should have been previously recorded in a copy of table 3D-1.
23.	If the measured O.D. is not within 5% of the desired value, adjust the gain pot (as per step 20) to increase or decrease the density, then repeat the previous two steps.
24.	Once the desired film density is achieved, record the mAs, dose, calibration number and O.D. in a copy of table 3D-14.
FOR EACH BREAKPOINT IN THE REMAINDER OF THIS SECTION, START WITH THE SUGGESTED DOSE AS PER TABLE 3D-13. AFTER THAT DOSE IS ACHIEVED, A FILM MUST BE EXPOSED AND THE O.D. VERIFIED. FURTHER DOSE ITERATIONS MAY BE REQUIRED TO ACHIEVE THE DESIRED OPTICAL DENSITY. ***DO NOT READJUST THE AEC BOARD GAIN POT AFTER THE 75KV KNEE BREAKPOINT IS CALIBRATED.*** **DOSE/DENSITY ADJUSTMENTS WILL ONLY BE DONE BY ADJUSTING THE CALIBRATION VALUES FOR THE OTHER KV BREAKPOINTS.**	

	55 KV BREAKPOINT CALIBRATION:
25.	Replace the 1.5 mm copper absorber previously installed with a 0.5 mm copper sheet. As before, ensure that the absorber fully blocks the X-ray field.
26.	Select the **55 kV** breakpoint.
27.	Make an exposure and note the dose. Use mA values as per table 3D-13.
28.	Adjust the 55 kV calibration numbers using the **+** or **-** buttons such that the actual dose is equal to the target dose at 55 kV for the selected film speed per table 3D-13. **DO NOT READJUST THE AEC BOARD GAIN POT.**

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

100 speed film screen					
Break point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kV knee pt.	1.5 mm Cu.	1025 µ/R	59.2 mAs	320 mA	320 mAs (MAX)
55 kV	0.5 mm Cu.	1808 µ/R	54 mAs	320 mA	320 mAs (MAX)
50 kV	0.5 mm Cu.	1832 µ/R	128 mAs	320 mA	320 mAs (MAX)
65 kV	1.0 mm Cu	1436 µ/R	44 mAs	320 mA	320 mAs (MAX)
110 kV	5.0 mm Cu.	1088 µ/R	24 mAs	200 mA	320 mAs (MAX)
130 kV	6.0 mm Cu.	848 µ/R	16 mAs	200 mA	320 mAs (MAX)
85 kV	4.0 mm Cu.	1060 µ/R	54 mAs	320 mA	320 mAs (MAX)
95 kV	4.5 mm Cu	1008 µ/R	44 mAs	320 mA	320 mAs (MAX)

200 speed film screen					
Break point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kVp knee pt.	1.5 mm Cu.	518 µ/R	30 mAs	250 mA	250 mAs (MAX)
55 kVp	0.5 mm Cu.	904 µ/R	26 mAs	250 mA	250 mAs (MAX)
50 kVp	0.5 mm Cu.	916 µ/R	64 mAs	250 mA	250 mAs (MAX)
65 kVp	1.0 mm Cu	718 µ/R	22 mAs	250 mA	250 mAs (MAX)
110 kVp	5.0 mm Cu.	544 µ/R	12 mAs	250 mA	250 mAs (MAX)
130 kVp	6.0 mm Cu.	484 µ/R	8 mAs	250 mA	250 mAs (MAX)
85 kVp	4.0 mm Cu.	530 µ/R	27 mAs	250 mA	250 mAs (MAX)
95 kVp	4.5 mm Cu	504 µ/R	22 mAs	250 mA	250 mAs (MAX)

400 speed film screen					
Break Point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kVp knee pt.	1.5 mm Cu.	259 µ/R	14.8 mAs	200 mA	200 mAs (MAX)
55 kVp	0.5 mm Cu.	452 µ/R	13 mAs	200 mA	200 mAs (MAX)
50 kVp	0.5 mm Cu.	458 µ/R	32 mAs	200 mA	200 mAs (MAX)
65 kVp	1.0 mm Cu	359 µ/R	11 mAs	200 mA	200 mAs (MAX)
110 kVp	5.0 mm Cu.	272 µ/R	6 mAs	200 mA	200 mAs (MAX)
130 kVp	6.0 mm Cu.	424 µ/R	4 mAs	200 mA	200 mAs (MAX)
85 kVp	4.0 mm Cu.	265 µ/R	13.5 mAs	200 mA	200 mAs (MAX)
95 kVp	4.5 mm Cu	252 µ/R	11 mAs	200 mA	200 mAs (MAX)

800 speed film screen					
Break Point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kVp knee pt.	1.5 mm Cu.	129 µ/R	7.4 mAs	110 mA	120 mAs (MAX)
55 kVp	0.5 mm Cu.	226 µ/R	6.5 mAs	100 mA	120 mAs (MAX)
50 kVp	0.5 mm Cu.	229µ/R	16 mAs	100 mA	120 mAs (MAX)
65 kVp	1.0 mm Cu	179 µ/R	5.5 mAs	100 mA	120 mAs (MAX)
110 kVp	5.0 mm Cu.	136 µ/R	3 mAs	100 mA	120 mAs (MAX)
130 kVp	6.0 mm Cu.	212 µ/R	2 mAs	100 mA	120 mAs (MAX)
85 kVp	4.0 mm Cu.	132 µ/R	6.7 mAs	100 mA	120 mAs (MAX)
95 kVp	4.5 mm Cu	126 µ/R	5.5 mAs	100 mA	120 mAs (MAX)

Table 3D-13: Breakpoint calibration factors

For SID's other than 40″ (100 cm) multiply the dose by the factor [new SID / 40 in.(100 cm)]^2

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

3D.5.1 Break point calibration worksheet

Record the final results in a copy of the table below. The final results are those obtained AFTER films have been developed to verify the correct O.D. at each breakpoint.

FILM SCREEN 1	**SPEED =**			
#1 BK. POINT = 75 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	DOSE =	CAL. NO. =	O.D. =

FILM SCREEN 2	**SPEED =**			
#1 BK. POINT = 75 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	DOSE =	CAL. NO. =	O.D. =

FILM SCREEN 3	**SPEED =**			
#1 BK. POINT = 75 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	DOSE =	CAL. NO. =	O.D. =

Table 3D-14: Breakpoint worksheet

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

Step	Action
29.	Load the test cassette with fresh film and install it in the image receptor. Using the same technique, expose the film and develop it.
30.	Measure the optical density. The optical density should be as per step 22.
31.	If the measured O.D. is not within 5% of the desired value, adjust the 55 kV calibration number using the **+** or **-** buttons, then repeat the previous two steps. **DO NOT READJUST THE AEC BOARD GAIN POT.**
32.	Once the desired film density is achieved, record the required values in a copy of table 3D-14.

	50 KV BREAKPOINT CALIBRATION:
33.	If special techniques are NOT used which require the 50 kV range, simply enter the 55 kV calibration number into the 50 kV breakpoint using the **+** and **-** buttons. Note that at approximately 55 kV and under, the screen film sensitivity becomes too low for practical AEC operation when used with a bucky.
34.	If the 50 kV range IS used, the 50 kV breakpoint must be calibrated. To do this select the 50 kV breakpoint. The 50 kV step will use the same absorber as used for the 55 kV step.
35.	Repeat steps 27 to 32 to calibrate the 50 kV breakpoint if desired, *substituting 50 kV where applicable in place of 55 kV*.

	65 KV BREAKPOINT CALIBRATION:
36.	Select the 65 kV breakpoint. Use copper thickness per table 3D-13 for the 65 kV breakpoint.
37.	Repeat steps 27 to 32 to calibrate the 65 kV breakpoint, *substituting 65 kV where applicable in place of 55 kV*.
38.	IN THE FOLLOWING STEPS, SELECT **>>** AND **<<** AS REQUIRED TO NAVIGATE BETWEEN THE TWO BREAKPOINT SCREENS (SCREEN 1 LISTS BREAKPOINTS 50 KV TO 95 KV, SCREEN 2 SHOWS BREAKPOINTS 110 AND 130 KV).

	110 KV BREAKPOINT CALIBRATION:
39.	Select the 110 kV breakpoint. Use copper thickness per table 3D-13 for the 110 kV breakpoint. Note that 200 mA is recommended for this step.
40.	Repeat steps 27 to 32 to calibrate the 110 kV breakpoint, *substituting 110 kV where applicable in place of 55 kV*.

	***130 KV BREAKPOINT CALIBRATION**:*
41.	If special high kV techniques are NOT used which require the 130 kV range, enter the 110 kV calibration number into the 130 kV breakpoint using the **+** and **-** buttons.
42.	If the 130 kV range IS used, the 130 kV breakpoint must be calibrated. To do this select the 130 kV breakpoint. Use copper thickness per table 3D-13 for the 130 kV breakpoint. Use 200 mA for this breakpoint as per table 3D-13.
43.	Repeat steps 27 to 32 to calibrate the 130 kV breakpoint if desired, *substituting 130 kV where applicable in place of 55 kV*.

	85 KV BREAKPOINT CALIBRATION:
44.	Select the 85 kV breakpoint. Use copper thickness per table 3D-13 for the 85 kV breakpoint.
45.	Repeat steps 27 to 32 to calibrate the 85 kV breakpoint, *substituting 85 kV where applicable in place of 55 kV*.

3D.5.0 AEC CALIBRATION (TABLE BUCKY) Cont

Step	Action
	95 KV BREAKPOINT CALIBRATION:
46.	Select the 95 kV breakpoint. Use copper thickness per table 3D-13 for the 95 kV breakpoint.
47.	Repeat steps 27 to 32 to calibrate the 95 kV breakpoint, *substituting 95 kV where applicable in place of 55 kV*.
48.	Select **<<** to return to the **AEC CALIBRATION** menu.

Step	Action
	FILM SCREEN 2 BREAKPOINT CALIBRATION:
49.	Select **FILM SCREEN 2.**
50.	Repeat steps 16 to 48 as described for film screen 1 ***except***: **WHEN CALIBRATING THE 75 KV KNEE BREAKPOINT FOR FILM SCREEN 2, DO NOT ADJUST THE AEC BOARD GAIN POT. DOSE ADJUSTMENTS MUST ONLY BE MADE BY VARYING THE BREAKPOINT CALIBRATION NUMBERS.** **FILM SCREEN 2 MUST BE THE NEXT HIGHEST FILM SPEED AFTER FILM SCREEN 1.**

Step	Action
	FILM SCREEN 3 BREAKPOINT CALIBRATION:
51.	Select **FILM SCREEN 3.**
52.	Repeat steps 16 to 48 as described for film screen 1 except: **WHEN CALIBRATING THE 75 KV KNEE BREAKPOINT FOR FILM SCREEN 3, DO NOT ADJUST THE AEC BOARD GAIN POT. DOSE ADJUSTMENTS MUST ONLY BE MADE BY VARYING THE BREAKPOINT CALIBRATION NUMBERS.** **FILM SCREEN 3 MUST BE THE HIGHEST FILM SPEED.**

3D.6.0 SHORT AEC TIME COMPENSATION (IF APPLICABLE)

Step	Action
	SECTION 3D.6.0 ONLY APPLIES FOR AEC BOARDS WITH SHORT AEC EXPOSURE TIME COMPENSATION (FIGURE 3D-9 OR 3D-11) ***IF AEC EXPOSURES LESS THAN APPROXIMATELY 15 MS ARE REQUIRED.***
1.	Select the image receptor to be short AEC time compensated, ie table bucky.
2.	Select the highest film speed used on the selected receptor, then select the **75 kV** breakpoint.
3.	Set the mA per table 3D-13 for the film speed being used. Reinstall the absorber as per table 3D-13 for the 75 kV breakpoint.
4.	Make an exposure and confirm the dose (or mAs) readings as previously recorded in table 3D-14.
5.	Reduce the absorber thickness such as to decrease the AEC exposure time to approximately 10 ms.
6.	Adjust the short AEC time compensation pot for the AEC channel being calibrated such that the dose (or mAs) is approximately the same as previously recorded (step 4). The short AEC time compensation potentiometer designations are given in table 3D-11.

3D.6.0 SHORT AEC TIME COMPENSATION (IF APPLICABLE) Cont

Step	Action
7.	Reduce the absorber thickness again such as to decrease the AEC exposure time to approximately 6 ms (but not less).
8.	Adjust the short AEC time compensation pot for the AEC channel being calibrated such that the dose (or mAs) is approximately the same as it was in step 6.
9.	The short AEC time compensation adjustments affect the AEC calibration at longer exposure times. Therefore, it may now be necessary to readjust the gain pot for the AEC channel being calibrated to restore the dose (or mAs) values to the values previously recorded in table 3D-14. Ensure that the absorber thickness and mA values are as per table 3D-13 when readjusting the AEC gain pot.
10.	Films should be exposed and developed, and the O.D. checked at the 75 kV breakpoint at AEC exposure times of approximately 6 ms and approximately 100 ms. If the film density is not acceptable at both short and long AEC exposure times, it will be necessary to iterate the adjustments of both the short AEC time compensation pot and the AEC gain pot by repeating steps 3 to 8.
11.	Repeat steps 1 to 10 for each image receptor (AEC channel) to be short AEC time compensated.

3D.7.0 AEC DENSITY CALIBRATION

The following screens are used for density calibration

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                   DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3


       EXIT
```

```
*TUBE?      0%HU        *DENS.  SE TUP*
-8:  -
-7:  -
-6:  -                                                    +
-5:  62%                                                  -
3200MS  EXIT                                      >>
```

```
*TUBE?      0%HU        *DENS.  SETUP*
-4:  50%
-3:  37%
-2:  25%                                                  +
-1:  12%                                                  -
3200MS   <<                                       >>
```

3D.7.0 AEC DENSITY CALIBRATION (Cont)

```
*TUBE?      0%HU       *DENS.  SETUP*
+1:  12%
+2:  25%
+3:  37%                                                    +
+4:  50%                                                    -
3200MS   <<                                        >>
```

```
*TUBE?      0%HU       *DENS.  SETUP*
+5:  62%
+6:  -
+7:  -                                                      +
+8:  -                                                      -
3200MS   <<                                    RETURN
```

Please note the following points regarding density calibration:

- Up to eight density plus and eight density minus steps are available. If ± 8 density steps are not required, the unwanted density steps may be programmed out per the procedure below. For example, if only ± 5 density steps are desired, then density steps ± 6, 7, 8 may be deprogrammed.

- Once the desired number of ± density steps are known, the relative minimum and maximum dose values must be determined. Typically the minimum density step will result in half (50%) of the nominal dose and the maximum density step will typically give double the nominal dose (100% increase). The nominal dose is the value that was recorded at **0** density in table 3D-14.

- The relative dose change per density step must be determined next. To do this, note the relative minimum and maximum dose as determined above (i.e. 50% at min density and 100% increase at max density), then calculate the number of - density steps and the number of + density steps that will be required.

  The relative dose change between density steps will then be the minimum density (i.e. 50) divided by the number of density minus steps or the maximum density (i.e. 100) divided by the number of density plus steps. This will yield the required dose increment for each density minus step and for each density plus step respectively.

  For ± 8 density steps, this gives a dose decrease of 6.25% per density minus step (8 steps x 6.25% per step = 50% dose at -8 density) or a dose increase of 12.5% per density plus step (8 steps x 12.5% per step = 100% dose increase at +8 density).

  Refer to table 3D-15 for two typical examples of density steps vs calibration numbers. For 8 minus density steps the dose decrease is 6.25% per step, and for 8 + density steps the dose increase is 12.5% per step as per the example calculation above.

  For 5 minus density steps the dose decrease is 10% per step, and for 5 + density steps the dose increase is 20% per step.

3D.7.0 AEC DENSITY CALIBRATION (Cont)

DENSITY STEP	CALIBRATION NUMBER (- 8 DENSITY = HALF THE DOSE, +8 DENSITY = DOUBLE THE DOSE)	DENSITY STEP	CALIBRATION NUMBER (- 5 DENSITY = HALF THE DOSE, +5 DENSITY = DOUBLE THE DOSE)
-8	50		
-7	44		
-6	38		
-5	31	-5	50
-4	25	-4	40
-3	19	-3	30
-2	13	-2	20
-1	6	-1	10
0 DENSITY: SHOWN FOR REFERENCE ONLY.			
+1	13	+1	20
+2	25	+2	40
+3	38	+3	60
+4	50	+4	80
+5	63	+5	99
+6	75		
+7	88		
+8	99		

Table 3D-15: Example density values

Step	Action
1.	Reselect **FILM SCREEN 1.** Replace the absorber previously used for kV breakpoint calibration with the 1.5 mm thick copper absorber.
2.	Reselect the 75 kV knee breakpoint.
3.	Select **<<** to return to the **AEC CALIBRATION** menu.
4.	Select **DENSITY SETUP.**
5.	Referring to table 3D-14, note the dose at 75 kV for film screen 1. This will be referred to as the **0** density dose.
6.	Select the highest density minus step desired i.e. **- 8** from the density setup menu. If it is not intended to use this step, select the highest density minus step to be used i.e. **- 5**, then set the unused steps to **-** to disable those steps. To disable density steps, press the **-** button to scroll down until the **-** symbol is displayed.
7.	Set the calibration number for the highest density minus step to the desired relative density value (example **50,** this will give approximately 1/2 the 0 density dose).
8.	Make an exposure and confirm that the measured dose is approximately the desired value.
9.	If the measured dose is not as expected, adjust the calibration number for that density step and repeat step 8.
10.	Select the next density step (i.e. **- 7**) and enter the appropriate calibration number for that step. Refer to table 3D-15 and the notes preceding table 3D-15. Repeat steps 8 and 9.
11.	Repeat the previous step for each remaining density minus step. Use the **>>** and **<<** buttons to navigate through the **DENS SETUP** menu in order to access all the density steps in this procedure.

3D.7.0 AEC DENSITY CALIBRATION (Cont)

Step	Action
12.	Set the calibration number for the highest density plus step to the desired relative density value (example **100,** this will result in approximately double the 0 density dose).
13.	Repeat step 8 and 9.
14.	Select the next lowest density step (i.e. **7**) and enter the appropriate calibration number for that step. Refer to table 3D-15 and notes preceding table 3D-15. Repeat steps 8 and 9.
15.	Repeat the previous step for each remaining density plus step. Use the **>>** and **<<** buttons to navigate through the **DENS SETUP** menu in order to access all the density steps.
16.	When the density setup is complete and verified via dose measurements, use the **<<** and **EXIT** buttons to return to the **AEC CALIBRATION** menu.

3D.8.0 RLF COMPENSATION

The following points should be noted regarding RLF compensation. RLF compensation is normally only needed if special techniques are used which result in AEC exposures greater than 100 ms.

- If perfect, film would provide linear density changes with linearly increasing exposure times. In reality, at longer exposures, film effectively becomes slower. This effect is known as reciprocity law failure. To compensate, exposure times must be increased at longer exposures.

  This compensation is achieved by increasing the AEC reference voltage at longer exposure times. RLF compensation is applied to three ranges (50-500 ms, 500-1000 ms, and 1000- 1500 ms) as shown below.

  The examples below are not meant to represent actual RLF compensation percentages in your installation. Actual values will need to be determined per the procedure following.

- Between 0 and 50 ms no RLF compensation is applied. Per figure 3D-14, the AEC reference voltage is constant at 1 unit between 0 and 50 ms.

- At 50 ms, RLF compensation = **10%** is applied. This means that the reference voltage will increase by 10% between 50 ms and 500 ms in a linear fashion. At 500 ms the reference voltage is then 1.0 X 1.10 = 1.10 units.

- At 500 ms, RLF compensation = **20%** is applied. This means that the reference voltage will increase by 20% between 500 ms and 1000 ms in a linear fashion. At 1000 ms the reference voltage is then 1.10 X 1.20 = 1.32 units.

- At 1000 ms, RLF compensation = **30%** is applied. This means that the reference voltage will increase by 30% between 1000 ms and 1500 ms in a linear fashion. At 1500 ms the reference voltage is then 1.32 X 1.30 = 1.72 units

- The rate of increase of the reference voltage beyond 1500 ms will be constant, up to limit of the B.U.T. (backup timer).

- The compensation curve resulting from the RLF values described above is depicted in the graph below.

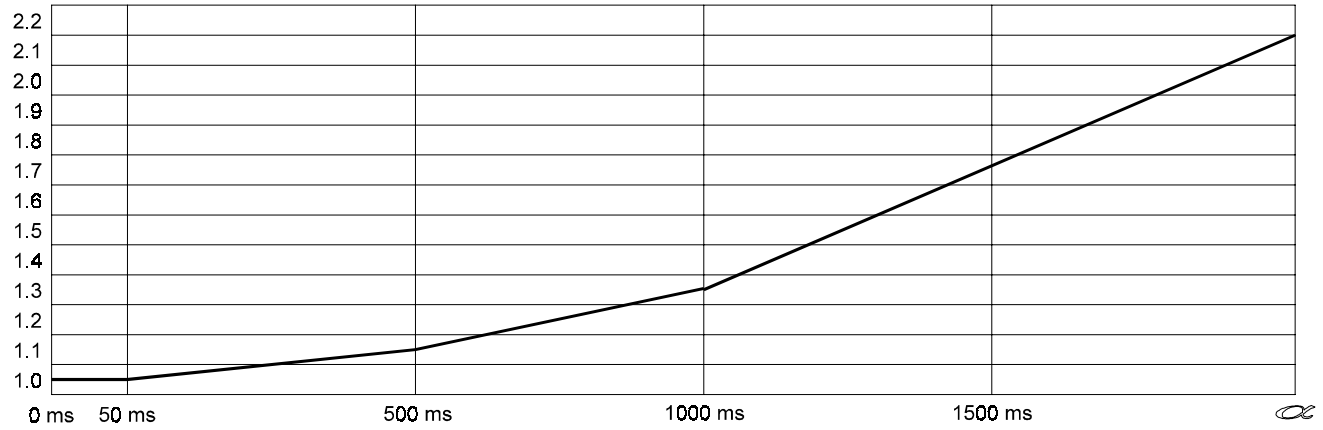


Figure 3D-14: Example RLF compensation curve

3D.8.0 RLF COMPENSATION (Cont)

The following screens are used for RLF compensation

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                        DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3


      EXIT
```

```
*TUBE?      0%HU        AEC CAL, F/S 1*
50KV:  84.0:                                        85KV:  42.8
55KV:  78.0:                                        95KV:  38.0
65KV:  66.0:                                                   +
75KV:  54.0                                                    -
3200MS   <<                                         >>
```

```
*TUBE?      0%HU        AEC CAL, F/S 1*
110KV:  34.0:
130KV:  28.0:
RLF COMPENSATION                                               +
MULT. SPOT  COMP:        0%                                    -
3200MS   <<
```

```
*TUBE?      0%HU        LF COMP, F/S 1*
50MSEC:    0%
500MSEC:    4%
1000MSEC:    0%                                                +
                                                               -
3200MS   <<
```

3D.8.0 RLF COMPENSATION (Cont)

Step	Action
1.	Place 2.0 mm of copper (pure grade) in front of the collimator, ensuring that the radiation is COMPLETELY blocked by the absorber.
2.	Select the slowest film screen combination to compensate. This will normally be **FILM SCREEN 1.**
3.	Select **>>.**
4.	Select **RLF COMPENSATION.**
5.	From the **LF COMP** menu, select **50MSEC** and set the value to **0** using the **+** or **-** buttons.
6.	Select mA appropriate to the film speed i.e. 100 mA for 100 speed film.
7.	Make an exposure and adjust the mA if necessary to give an exposure time of approximately 50 ms.
8.	Load a test cassette with fresh film and install it in the image receptor.
9.	Make an exposure using the same techniques. Record the mAs, then develop the film.
10.	Note the O.D. This should be within 10% of the O.D. that was noted during AEC calibration.
11.	Make an exposure and reduce the mA to give an exposure time of approximately 500 ms.
12.	Make an exposure using the same techniques. Record the mAs.
13.	Enter an RLF offset at **50MSEC** to give an mAs increase of approximately 10%.
14.	Load a test cassette with fresh film and install it in the image receptor. Make an exposure and develop the film.
15.	If the measured O.D. is not within 5% of the value in step 10, adjust the 50 ms RLF offset value as appropriate using the **+** and **-** buttons.
16.	Repeat steps 14 and 15 until the required O.D. is achieved.
17.	Make an exposure and reduce the mA to give an exposure time of approximately 1000 ms.
18.	Select the **500MSEC** RLF adjustment and set the value to **0** using the **+** or **-** buttons.
19.	Make an exposure using the same techniques. Record the mAs.
20.	Enter an RLF offset at **500MSEC** to give an mAs increase of approximately 20%.
21.	Load the test cassette with fresh film and install it in the image receptor. Make an exposure and develop the film.
22.	If the measured O.D. is not within 5% of the value in step 10, adjust the 500 ms RLF offset value as appropriate using the **+** and **-** buttons.
23.	Repeat steps 21 and 22 until the desired density is achieved.
	THE FOLLOWING STEPS ONLY APPLY IF TECHNIQUES ARE USED RESULTING IN AEC EXPOSURE TIMES GREATER THAN APPROXIMATELY 1500 MS.
24.	Make an exposure and reduce the mA such as to give an exposure time of approximately 1500ms.
25.	Select the **1000MSEC** RLF adjustment and set the value to **0** using the **+** or **-** buttons.
26.	Make an exposure using the same techniques. Record the mAs.
27.	Enter an RLF offset at **1000MSEC** to give an mAs increase of approximately 30%.
28.	Load the test cassette with fresh film and install it in the image receptor. Make an exposure and develop the film.
29.	If the measured O.D. is not within 5% of the value in step 10, adjust the 1000 ms RLF offset value as appropriate using the **+** and **-** buttons.
30.	Repeat steps 28 and 29 until the desired density is achieved.
31.	Select **BACK** three times to return to the **AEC CALIBRATION** menu.
32.	Repeat steps 2 to 31 for **FILM SCREEN 2** and **FILM SCREEN 3** if required.

3D.9.0 MULTIPLE SPOT COMPENSATION

The following screens are used for multiple spot compensation

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                   DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3


      EXIT
```

```
*TUBE?      0%HU        AEC CAL, F/S 1*
50KV:  84.0:                                    85KV:  42.8
55KV:  78.0:                                    95KV:  38.0
65KV:  66.0:                                              +
75KV:  54.0                                               -
3200MS   <<                                  >>
```

```
*TUBE?      0%HU        AEC CAL, F/S 1*
110KV:  34.0:
130KV:  28.0:
RLF COMPENSATION                                          +
MULT. SPOT COMP:        0%                                -
3200MS   <<
```

- Multiple spot compensation may be required when doing multiple exposures on a single film. In this mode of serial recording, the X-ray field is usually coned down to a small area. Due to the lack of scatter and possible AEC field cutoff, an AEC density offset may be added if required. This offset is known as multiple spot compensation.

- In order to activate the multiple spot compensation feature, the R & F table must supply a closed dry contact when the SFD is operated in multi-spot mode. The multi-spot input to the generator is at TB5 pins 11 and 12 on the room interface board.

3D.9.0 MULTIPLE SPOT COMPENSATION (Cont)

Step	Action
1.	Place 4.0 mm of copper (pure grade) in front of the collimator, ensuring that the radiation is COMPLETELY blocked by the absorber.
2.	Select the slowest film screen combination to compensate. This will normally be **FILM SCREEN 1.**
3.	Select **>>.**
4.	Select **MULT SPOT COMP.**
5.	Enter the value **0%** using the **+** and **-** buttons.
6.	Select 85 kV via the kV **+** or **-** buttons in the radiography section of the console.
7.	Select mA appropriate to the film speed per table 3D-13.
8.	Load the test cassette with fresh film and install it in the SFD.
9.	Make an exposure and record the mAs, then develop the film.
10.	Verify that the film is evenly exposed, and that the O.D. is the desired value
11.	Enable the SFD multi-spot function, then make several exposures and record the mAs.
12.	Develop the film and record the O.D. for each exposure.
13.	If the measured optical densities are not within 5% of the desired value, enter a multi-spot compensation offset percentage that increases or decreases the mAs as appropriate using the **+** and **-** buttons.
14.	Repeat steps 8 to 13 until the desired O.D. is achieved on all exposures.
15.	Select **<<** three times to return to the **AEC CALIBRATION** menu.
16.	Repeat steps 2 to 15 for **FILM SCREEN 2** and **FILM SCREEN 3** if required.
17.	Select **EXIT** to return to the **GEN CONFIGURATION** menu.
18.	Select **EXIT SETUP** to return to the normal operating mode.

3D.10.0 AEC CALIBRATION (WALL BUCKY)

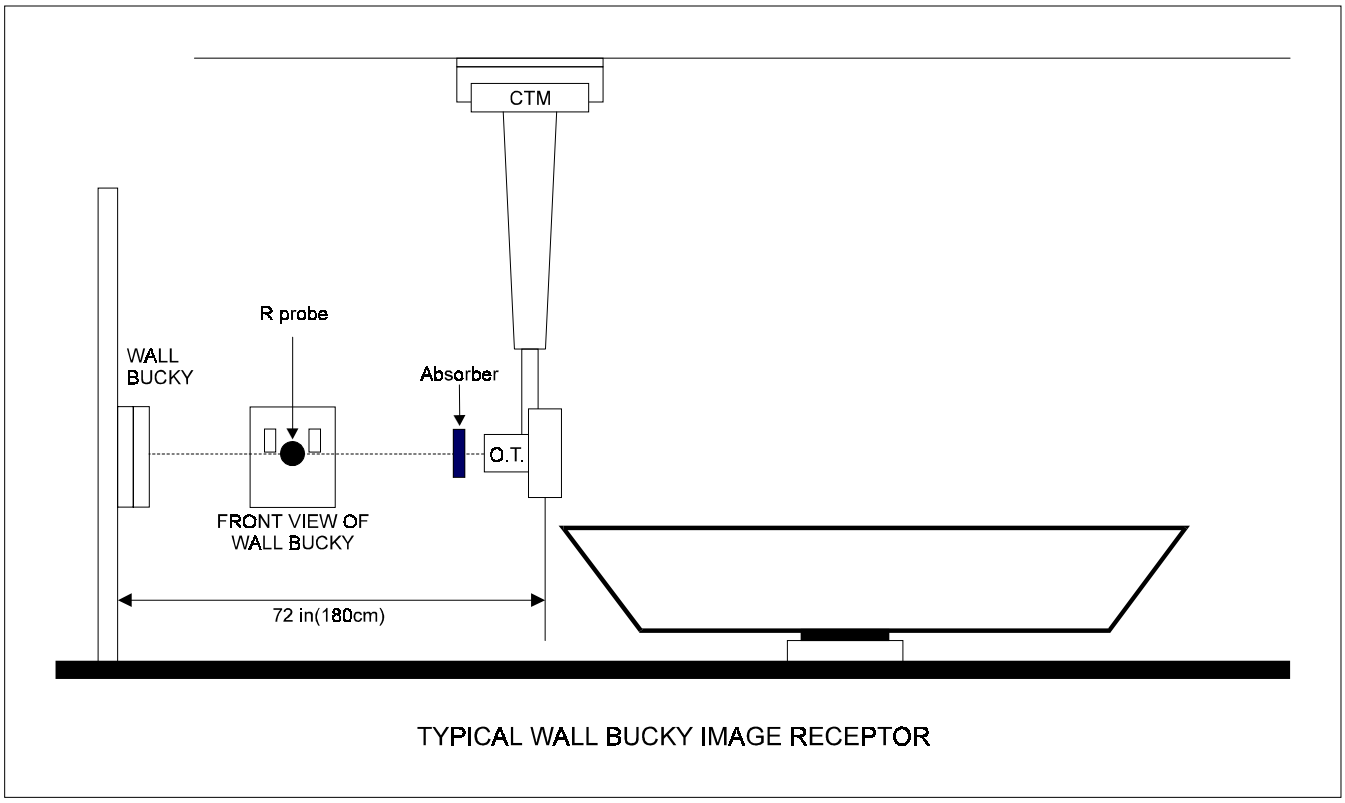


Figure 3D-15: Equipment setup for wall bucky AEC calibration

Please note the following points regarding wall bucky calibration:

- If the wall bucky is dedicated to chest radiography, a focused grid with a 10:1 or 12:1 ratio should be used along with an SID of 72 in (180 cm).

- If the wall bucky will be used for conventional as well as chest radiography, then two grids should ideally be used. See the note at the bottom of this page.

A reasonable compromise if a single grid must be used is a 10:1 ratio, 60 in (150 cm) grid.

NOTE: ***SINCE MOST WALL BUCKY'S ARE USED AT 40 AND 72" (100 AND 180 CM) SID, THE GRID MUST BE CHOSEN WITH CARE WITH RESPECT TO CUT-OFF. A TYPICAL GRID WILL HAVE AN 8:1 RATIO, WITH 85 LINE PAIR/INCH OR 10:1 RATIO WITH 150 LINE PAIR/INCH (STATIONARY). TYPICALLY, 400 SPEED FILM SCREEN WILL BE USED WITH 90 SECOND PROCESSING.***

3D.10.0 AEC CALIBRATION (WALL BUCKY) Cont

Grid Absorption

The following information may aid in selecting a grid and/or estimating doses in front of the bucky if required: The percentages listed are approximate.

- A 10:1 ratio 60 in (150 cm) focused grid will exhibit the following absorption when measured 5 in (13 cm) from center: At 72 in (180 cm) absorption = 18%
  At 40 in (100 cm) absorption = 40%

- A 12:1 ratio 60 in (150 cm) focused grid will exhibit the following absorption when measured 5 in (13 cm) from center: At 72 in (180 cm) absorption = 20%
  At 40 in (100 cm) absorption = 50%

- A 10:1 ratio 72 in (180 cm) focused grid will exhibit the following absorption when measured 5 in (13 cm) from center: At 40 in (100 cm) absorption = 65%

- A 12:1 ratio 72 in (180 cm) focused grid will exhibit the following absorption when measured 5 in (13 cm) from center: At 40 in (100 cm) absorption = 75%

- A 10:1 ratio 40 in (100 cm) focused grid will exhibit the following absorption when measured 5 in (13 cm) from center: At 72 in (180 cm) absorption = 65%

- A 12:1 ratio 40 in (100 cm) focused grid will exhibit the following absorption when measured 5 in (13 cm) from center: At 72 in (180 cm) absorption = 75%

NOTE: ***BREAKPOINT CALIBRATIONS MAY HAVE BEEN DONE FOR ALL THREE FILM SCREEN COMBINATIONS DURING TABLE BUCKY AEC CALIBRATION. IF SO, THE REMAINING IMAGE RECEPTORS MUST USE THE CALIBRATION CURVES PREVIOUSLY ESTABLISHED FOR THOSE FILM SCREENS.***

IF AN UNUSED FILM SCREEN COMBINATION IS AVAILABLE FOR WALL BUCKY USE, IT IS SUGGESTED THAT TWO RECEPTOR SELECTOR BUTTONS ON THE CONSOLE BE ASSIGNED TO SELECT THE WALL BUCKY. THE FIRST WALL BUCKY SELECTOR SHOULD BE USED FOR 40″ (100 CM) SID'S WITH THE APPROPRIATE PREVIOUSLY CALIBRATED FILM SCREEN. THE SECOND WALL BUCKY SELECTOR SHOULD THEN BE USED WITH THE PREVIOUSLY UNCALIBRATED FILM SCREEN AT 72″(180 CM) SID'S.

THIS METHOD WILL ALLOW THE GRID TO BE OPTIMIZED FOR EACH SID, AS A SEPARATE DEDICATED FILM SCREEN WITH ITS OWN CALIBRATION CURVE CAN BE ASSIGNED TO THE 72″(180CM) SID.

3D.10.0 AEC CALIBRATION (WALL BUCKY) Cont

Step	Action
	USE OF ONE FILM SCREEN FOR BOTH SID'S USING PREVIOUSLY CALIBRATED FILM SCREENS
1.	Set up the X-ray tube stand as shown in figure 3D-15.
2.	Align the tube stand and wall bucky such that the central ray is centered relative to the image receptor.
3.	Open up the collimator to expose all three fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4.	Place the R probe at the film plane, i.e. behind the grid. If this cannot be done, then attach the probe to the front of the bucky. Ensure that the R-probe is located directly under the central ray. The R meter must be set to measure in the micro-R range.
5.	Place 1.5 mm of copper (pure grade) in front of the collimator, ensuring that the radiation is COMPLETELY blocked by the absorber.
6.	Select the wall bucky image receptor.
7.	Select the slowest film screen used for the wall bucky, then select the appropriate mA for that film screen per table 3D-13 (example 320 mA for 100 speed film). Select 75 kV, large focus, center field.
8.	Make an exposure and note the dose and mAs.
9.	Referring to table 3D-14, select the previously established dose required at the 75 kV knee breakpoint for the film speed being calibrated. **Note that the dose values in the table are based on a specific R-probe placement during table bucky calibration (either at the film plane, or alternately in front of the bucky). If the probe placement for wall bucky calibration is not the same as it was for table bucky calibration, use the estimated dose correction factor in this subsection under *GRID ABSORPTION*.**
10.	Adjust the required gain potentiometer on the AEC board (see note below) while taking exposures until the dose noted in the previous step is obtained. • **CHANNEL 2 ON THE AEC BOARD IS TYPICALLY USED FOR THE WALL BUCKY AEC CHAMBER. YOUR INSTALLATION MAY USE A DIFFERENT CHANNEL ON THE AEC BOARD. *DO NOT READJUST THE GAIN POT FOR THE CHANNEL THAT WAS PREVIOUSLY CALIBRATED (FOR TABLE BUCKY).*** • **REFER TO TABLE 3D-10 FOR THE AEC BOARD GAIN POTENTIOMETER (GAIN POT) DESIGNATIONS FOR THE VARIOUS AEC BOARDS.**
11.	Load the test cassette with fresh film and install it in the image receptor. Using the same technique, expose the film and develop it.
12.	Measure the O.D. The desired value should have been previously recorded in a copy of table 3D-1.
13.	If the measured O.D. is not within 5% of the desired value, adjust the gain pot (as per step 10) to increase or decrease the density, then repeat the previous two steps.
14.	Change the SID to 40″ (100 CM) and repeat steps 11 to 13. Adjust the gain pot if necessary to achieve an acceptable compromise between both SID's.
14.	Verify the O.D. at a range of different kV's.

	USE OF TWO FILM SCREENS (ONE FOR EACH SID) USING ONE PREVIOUSLY CALIBRATED FILM SCREEN AND ONE UNCALIBRATED FILM SCREEN
15.	Select the wall bucky image receptor via the selector configured for the 40″ (100 CM) SID.
16.	Repeat steps 1 to 13 at the 40″ (100 CM) SID position using the appropriate previously calibrated film screen.

3D.10.0 AEC CALIBRATION (WALL BUCKY) Cont

Step	Action
17.	Verify the O.D. at a range of different kV's.
18.	Switch the generator OFF. Re-enter the programming mode as detailed in the TABLE BUCKY AEC calibration section.
19.	Select the wall bucky image receptor via the selector configured for the 72″ (180 CM) SID.
20.	Calibrate the film screen assigned to this SID as per the table bucky procedure. The calibration pot is NOT to be adjusted during this procedure (this was calibrated in the preceding procedure). All breakpoints, including the 75 kV knee breakpoint, are to be calibrated by adjusting the calibration numbers ONLY.
21.	When complete, exit the **AEC CALIBRATION** and **GEN CONFIGURATION** menu.

3D.11.0 AEC CALIBRATION (AUX, SFD, ETC)

The remaining image receptors are calibrated in a similar manner to the table bucky receptor. Only the gain pot for that channel is to be adjusted at the slowest film screen used on that receptor. DO NOT READJUST THE GAIN POT FOR PREVIOUSLY CALIBRATED RECEPTORS, AND DO NOT READJUST THE CALIBRATION VALUES IN THE AEC CALIBRATION MENU FOR PREVIOUSLY CALIBRATED FILM SCREENS.

Refer to 3D.2.9 if a PMT is to be used for AEC during digital acquisition or spot film work.

THE *MEMORY* SETTING THAT WAS TEMPORARILY CHANGED TO *OFF* IN SECTION 3D.5.0 STEP 11 MAY NOW BE RESET TO THE DESIRED VALUE.

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CHAPTER 3

SECTION 3E

ABS CALIBRATION

CONTENTS:

3E.1.0 INTRODUCTION

3E.1.1 Overview of ABS Operation

Refer to figure 3E-1, this is a block diagram of the ABS system.

X-rays pass through the patient and excite the input cesium phosphor of the image intensifier (I.I.). This will cause the output of the I.I. to fluoresce and project the image to the TV camera via the collimating lens. A sample of the light output is then sensed by a photodiode or photomultiplier tube (PMT), or composite or proportional video will be fed back from the camera.

The feedback signal is processed by the ABS circuits on the generator interface board. The result, regardless of the type of ABS sensor used, will be a DC voltage proportional to the brightness of the image. This DC signal is then processed by the generator CPU board. The CPU compares the feedback voltage with a reference value determined by dose rate, mA, kVp, and mA ranges set during ABS calibration. The CPU will attempt to maintain constant image brightness by varying the kVp and/or mA output of the HF power supply according to a predetermined algorithm.

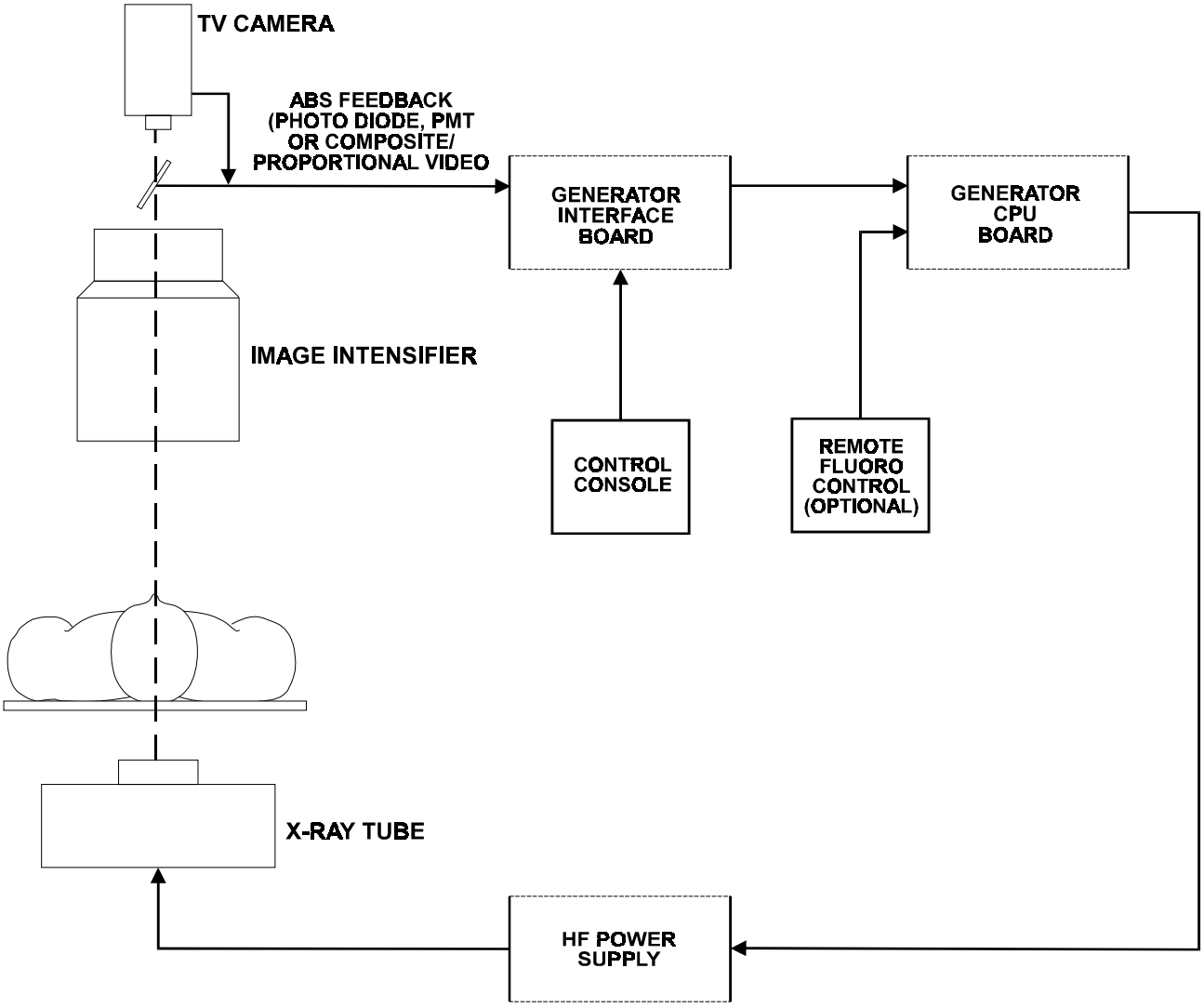


Figure 3E-1: ABS block diagram

3E.1.2 Image Intensifier Light Output

The following variables affect the transmitted light output of an I.I. tube.

- Image Intensifier gain.
- Field size - input to output.
- System components.
- Choice of X-ray techniques.

Image Intensifier Gain.

Image tube gain is affected by two different factors, the ratio of the input to output phosphor area and the electron gain due to the electron acceleration from the cathode to anode. A third effect that slowly reduces the I.I. tube's gain is age. The emissivity of the cesium cathode decays with time and usage.

Gain = Area of input divided by the area of the output multiplied by the energy of a photon
($E = hc/\lambda$ [where h = Plank's constant, c = speed of light and λ is the light wavelength])

Example: Consider the difference of I.I. tube gain when a 12 inch I.I. tube is switched between 6 inches and 12 inches.

Gain with tube in NORMAL mode:
Gain =$(6 \text{ X } 6 \text{ X } \pi)/(.5 \text{ X } .5 \text{ x } \pi) = 144 \text{ X E}$

Gain with tube in the MAG mode:
Gain =$(3 \text{ X } 3 \text{ X } \pi)/(.5 \text{ X } .5 \text{ x } \pi) = 36 \text{ X E}$

Field Size - Input to Output.

Most modern I.I. tubes are the multi-mode type where the effective input area may be changed per the nature of the procedure. To change the field size of an I.I. tube when a MAG mode is selected, the electron beam over-scans the output target. This in effect reduces the ratio of input size to output size and reduces the gain or light output of the I.I. tube.

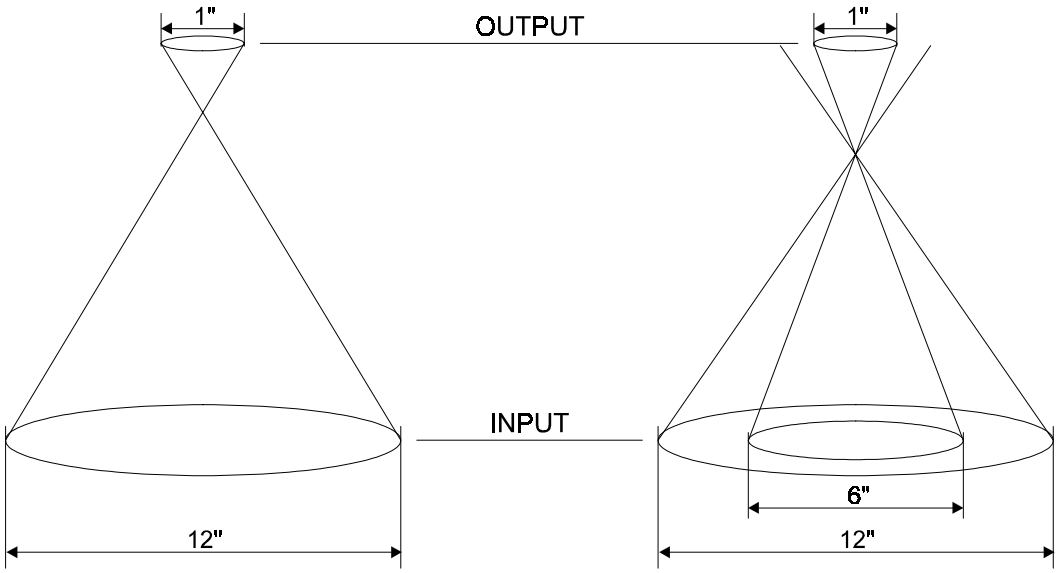


Figure 3E-2: I.I. input and output area

3E.1.3 ABS Pickup Devices

Shown below are pictorial representations of the three basic types of light sensors which generate the DC reference signal used by the generator. These are simplified schematics only, refer to section 3E-2.0. for actual wiring of the ABS pickup device.

Photo-multiplier tube

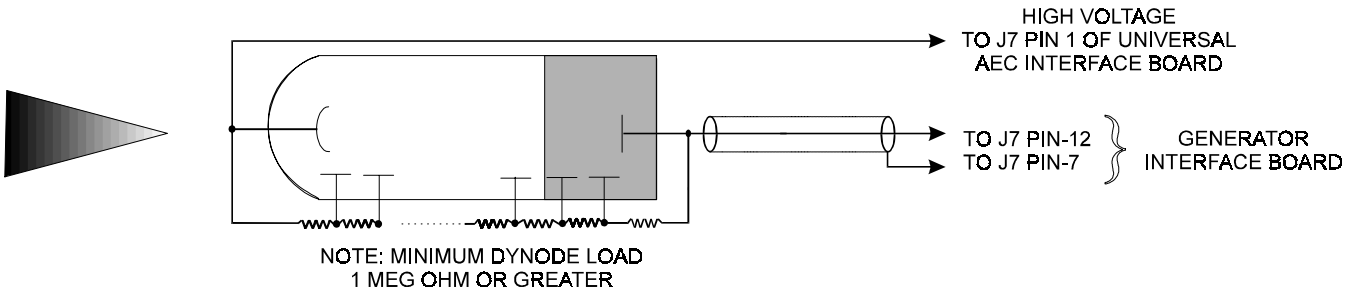
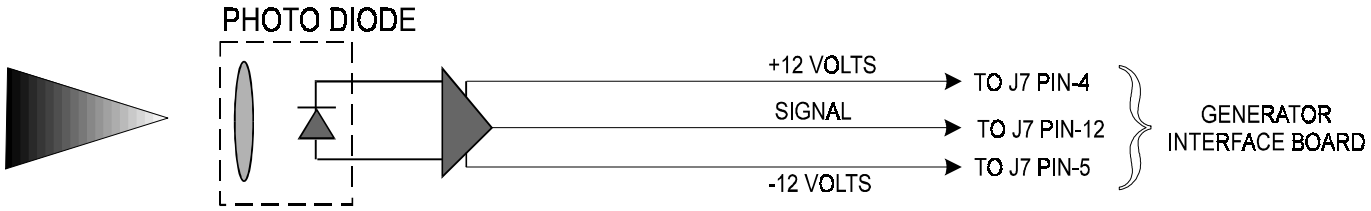


Photo Diode



Composite Video or Proportional DC

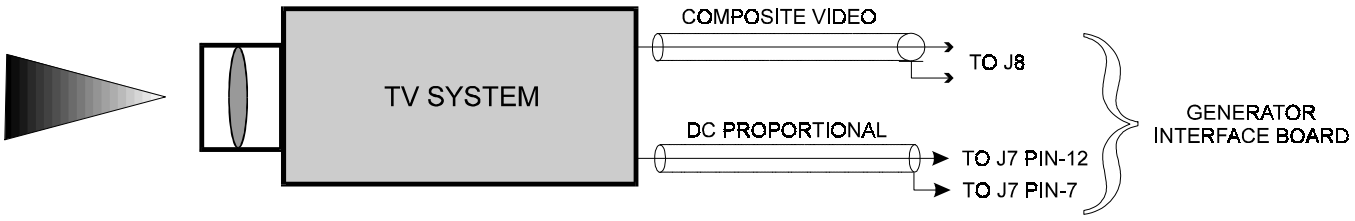


Figure 3E-3: ABS Pickup Devices

3E.1.4 Required Test Equipment

The following test equipment is required for ABS calibration.

- Resolution test pattern for imaging focusing.
- Central ray alignment fixture.
- Collimator centering test pattern.
- A selection of Al filters for HVL determination.
- A selection of body absorbers such as sheets of pure copper (1.0 to 7.5 mm). Refer to table 3E-1 for equivalent thickness of various absorbers.

3E.1.5 Absorber Equivalents

Table 3E-1 shows the absorption equivalency for copper, water and aluminum. These values are based on 75 kVp.

Cu (mm/in)	Water (cm/in)	Al 1100 (cm/in)
0.5 / .020	7.6 / 3.0	1.27 / 0.5
1.0 / .039	15.2 / 6.0	2.54 / 1.0
2.0 / .079	30.5 / 12.0	5.33 / 2.1
3.0 / .118	45.8 / 18.0	7.87 / 3.1
4.0 / .157	*	*
5.0 / .196	*	*
6.0 / .236	*	*
7.0 / .276	*	*
8.0 / .315	*	*

Table 3E-1: Equivalent thickness of various absorbers

*** =** Water/aluminum thickness at these values too great to be practical.

3E.2.0 ABS PICKUP INSTALLATION/WIRING

Sections 3E.1.3 and 3E.2.1 present an overview of the various ABS pickup types that may be used with the Millenia and Indico 100 family of generators. The generator must be specifically configured to accept each pickup type as per table 3E-2 and sections 3E.2.3, 3E.2.4, 3E.2.5 and 3E.2.6.

PLEASE NOTE THAT THE GENERATOR IS FACTORY CONFIGURED FOR ONE SPECIFIC TYPE OF ABS PICKUP ONLY. REFER TO THE CUSTOMER PRODUCT DESCRIPTION FORM IN CHAPTER 1 SECTION D FOR THE FACTORY CONFIGURED ABS COMPATIBILITY OF THIS GENERATOR.

3E.2.1 Overview

The generator has been factory configured to to be compatible with one of the following ABS pickup types. Field reconfiguration to accept other ABS pickup types, listed below, is possible if required.

- PMT (photo multiplier tube).
- Light sensitive optical diode. The output may be 0 to +5 VDC, 0 to -5 VDC, or +/- VDC centered at 0 VDC.
- A proportional (to the brightness of the I.I) DC voltage. The output polarity may be 0 to +5 VDC or 0 to -5 VDC.
- A terminated or non terminated composite video signal.

Refer to chapter 1E for the AEC board and generator interface board location in your generator.

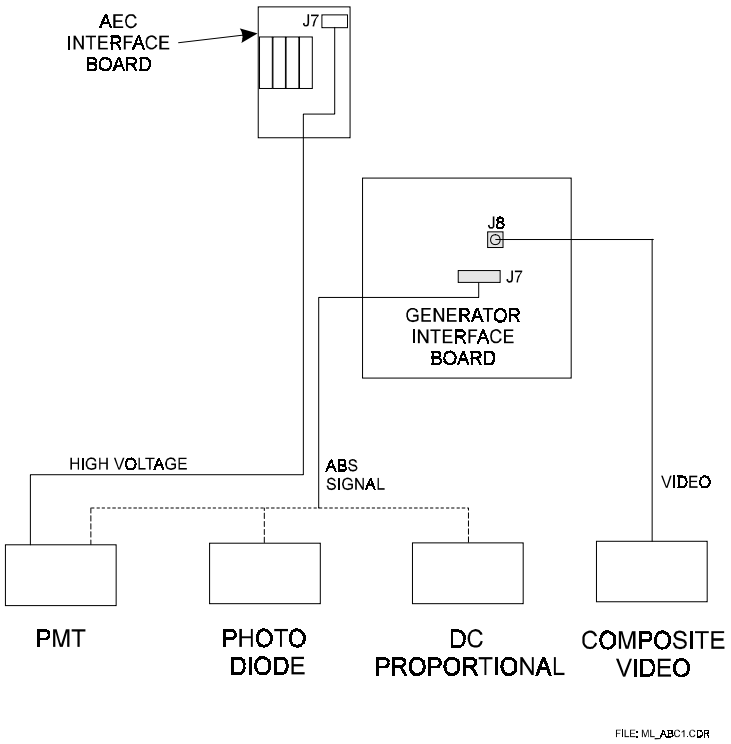


Figure 3E-4: ABS interface to the generator (overview)

3E.2.2 ABS Jumper Matrix.

The table below details the generator interface board jumper positions as required to be compatible with the listed ABS pickups. Refer to the generator interface board schematic 732175 sheet 2 in conjunction with this table. This table should be used in conjunction with sections 3E.2.3, 3E.2.4 3E.2.5, and 3E.2.6.

ABS PICKUP TYPE	GENERATOR INTERFACE BOARD INPUTS & JUMPER CONFIGURATIONS								
	INPUT	JW4	JW5	JW11	JW12	JW13	JW19	JW20	JW21
Photo Multiplier Tube	J7	OUT	*	PINS 1-2	OUT	OUT	*	*	PINS 2-3
Photo Multiplier Tube	J8	OUT	*	PINS 1-2	OUT	OUT	PINS 1-2	IN	PINS 2-3
Photo Diode (negative output)	J7	OUT	*	PINS 1-2	OUT	OUT	*	*	PINS 2-3
Photo Diode (positive output)	J7	OUT	*	PINS 2-3	OUT	OUT	*	*	PINS 2-3
Photo Diode 0-5 VDC neg/pos	J7	OUT	*	PINS 2-3	OUT	OUT	*	*	PINS 2-3
Proportional DC 0-5 VDC positive	J7	OUT	*	PINS 2-3	OUT	OUT	*	*	PINS 2-3
Proportional DC 0-5 VDC positive	J8	OUT	*	PINS 2-3	OUT	OUT	PINS 1-2	OUT	PINS 2-3
Proportional DC 0-5 VDC negative	J7	OUT	*	PINS 1-2	OUT	OUT	*	*	PINS 2-3
Proportional DC 0-5 VDC negative	J8	OUT	*	PINS 1-2	OUT	OUT	PINS 1-2	OUT	PINS 2-3
Composite video terminated 75 Ω	J8	OUT	IN	PINS 3-4	OUT	IN	PINS 2-3	IN	PINS 2-3
Composite video high impedance	J8	IN	OUT	PINS 3-4	OUT	IN	PINS 2-3	IN	PINS 2-3
Via optional expansion board in digital system	Via J13	OUT	*	*	*	*	*	*	PINS 1-2

* = Don't care i.e. jumper may be in any position

NOTE: TABLE 3E-2 INDICATES THE OPTION OF CONNECTING THE OUTPUTS FROM A PMT OR PROPORTIONAL DC TO J8 INSTEAD OF J7. THIS ALTERNATE CONNECTION IS <u>NOT</u> SHOWN IN THE SIMPLIFIED PICTORIAL DIAGRAMS 3E-3 OR 3E-4.

Table 3E-2: ABS jumper matrix

WARNING: ***SWITCH OFF THE GENERATOR AND ENSURE THAT ALL CAPACITORS ARE DISCHARGED BEFORE CONNECTING ANY ABS PICKUP DEVICES***

3E.2.3 PMT (Photo Multiplier Tube)

NOTE: The generator must be fitted with the "Universal AEC Board" assembly if using a PMT. The high voltage supply for the PMT is located on this assembly.

1. Dress the PMT cable from the imaging system such as to allow the dynode high voltage lead to plug into the "universal AEC interface board" at J7. Refer to figure 3E-4. J7 is the high voltage output for the PMT, all pins on this connector are connected in parallel and thus any of the 4 pins on J7 may be used. Ensure that the high voltage lead is rated at 1000 VDC minimum.
   NOTE: The total resistive load of all dynodes must be greater than 1 megohm to prevent excess PMT power supply loading.

2. Dress the signal (coax) cable from the PMT to allow it to connect to J7 on the generator interface board. Wire to J7 as per figure 3E-3. Alternately, the PMT output may be connected to BNC connector J8 on the generator interface board.

3. Ensure that there is sufficient slack in the cables such that the cabinet door does not strain these cables when opening and closing. Secure the cables in place such as to prevent mechanical stress on the connections.

4. The signal ground must be at the generator interface board only to avoid ground loops.

5. Position the jumpers on the generator interface board as per table 3E-2 for ***Photo Multiplier Tube***, selecting the correct configuration depending on whether the input is at J7 or J8.

6. The PMT high voltage calibration will be done at a later step.

3E.2.4 Photo Diode

1. Dress the signal cable from the photo diode circuit to allow it to connect to J7 on the generator interface board. Connect the photodiode to J7 as follows: Output signal to pin 12, ground to pin 7, +12 VDC to pin 4, and -12 VDC if used to pin 5.

2. Ensure that there is sufficient slack in the cable such that the cabinet door does not strain this cable when opening and closing. Secure the cables in place such as to prevent mechanical stress on the connections.

3. Note that there are three types of photo diodes for this application with outputs as listed below:

   - a zero to positive DC voltage for increasing light flux
   - a zero to negative DC voltage for increasing light flux
   - a negative DC voltage to positive DC voltage for increasing light flux. The required dose is set for 0 volts. The output will be negative for reduced light due to increased patient absorption, then swinging positive for increased light due to reduced patient absorption.

4. Position the jumpers on the generator interface board as per table 3E-2 for ***Photo Diode.*** Please ensure that the correct configuration is selected per your photo diode type as detailed above.

3E.2.5 DC Proportional

1. Dress the signal cable from the camera to allow it to connect to J7 on the generator interface board. Wire to J7 as per figure 3E-3. Alternately, the DC proportional signal output may be connected to BNC connector J8 on the generator interface board.

2. Ensure that there is sufficient slack in the cable such that the cabinet door does not strain this cable when opening and closing. Secure the cable in place such as to prevent mechanical stress on the connections.

3. Position the jumpers on the generator interface board as per table 3E-2 for ***Proportional DC***, selecting the correct configuration depending on whether the input is at J7 or J8 and whether the polarity is negative or positive.

3E.2.6 Composite Video

1. Dress the composite video output from the camera to allow it to connect to J8 on the generator interface board.

2. Ensure that there is sufficient slack in the cable such that the cabinet door does not strain this cable when opening and closing. Secure the cable in place such as to prevent mechanical stress on the terminations.

3. Position the jumpers on the generator interface board as per table 3E-2 for ***Composite Video***, selecting the correct configuration depending on whether the video is 75 Ω terminated or high impedance (it must be determined beforehand whether the 75 Ω termination must be made at the generator).

3E.3.0 ABS SETUP

Before the ABS system can be calibrated, the imaging system must be functional and properly set up. Please verify the following:

- Image intensifier and its power supply are functional.
- TV camera calibrated for this application.
- All beam attenuating devices are in place.
- Table top is in position.
- Fluoro grid is in path of X-ray beam.
- Imaging system is in the operational position.
- Imaging collimator functional.
- Collimator opening varies as S.I.D. is changed. (S.I.D. = source-image distance)
- Collimator opening varies as the image intensifier's MAG mode switch is changed.
- The ABS pickup device (as per the previous section) must be installed and functional.
- Sufficient filters are added to the X-ray tube to provide the required HVL.
- The fluoro imaging and receptor devices have been programmed. Reference chapter-3, section C
- kVp and mA must be in calibration. Reference chapter-4

CAUTION: ***PROCEDURES IN THE FOLLOWING SECTIONS REQUIRE THE PRODUCTION OF X-RAYS. IT IS THE RESPONSIBILITY OF THE INSTALLER TO FOLLOW ESTABLISHED GUIDELINES TO PROTECT ALL PERSONNEL FROM RADIATION EXPOSURE.***

3E.3.1 Dose Limits

This procedure sets the maximum kV allowed for each mA step in both manual and ABS mode of operation.

CAUTION: ***MAXIMUM INPUT DOSE VALUE IS USUALLY GOVERNED BY LOCAL, STATE OR COUNTRY REGULATIONS. THESE LIMITS MUST BE DETERMINED IN ADVANCE OF ATTEMPTING DOSE LIMITS SETUP, AND ADHERED TO DURING GENERATOR CALIBRATION.***

NOTE: ***REFER TO LOCAL REGULATIONS TO DETERMINE THE REQUIRED DISTANCE BETWEEN THE FOCAL SPOT AND RADIATION DETECTOR. THIS FOCAL SPOT TO DETECTOR DISTANCE MUST BE USED WHEN SETTING UP THE RADIATION DETECTOR FOR DOSE LIMITS CALIBRATION.***

3E.3.1 Dose Limits (Cont)

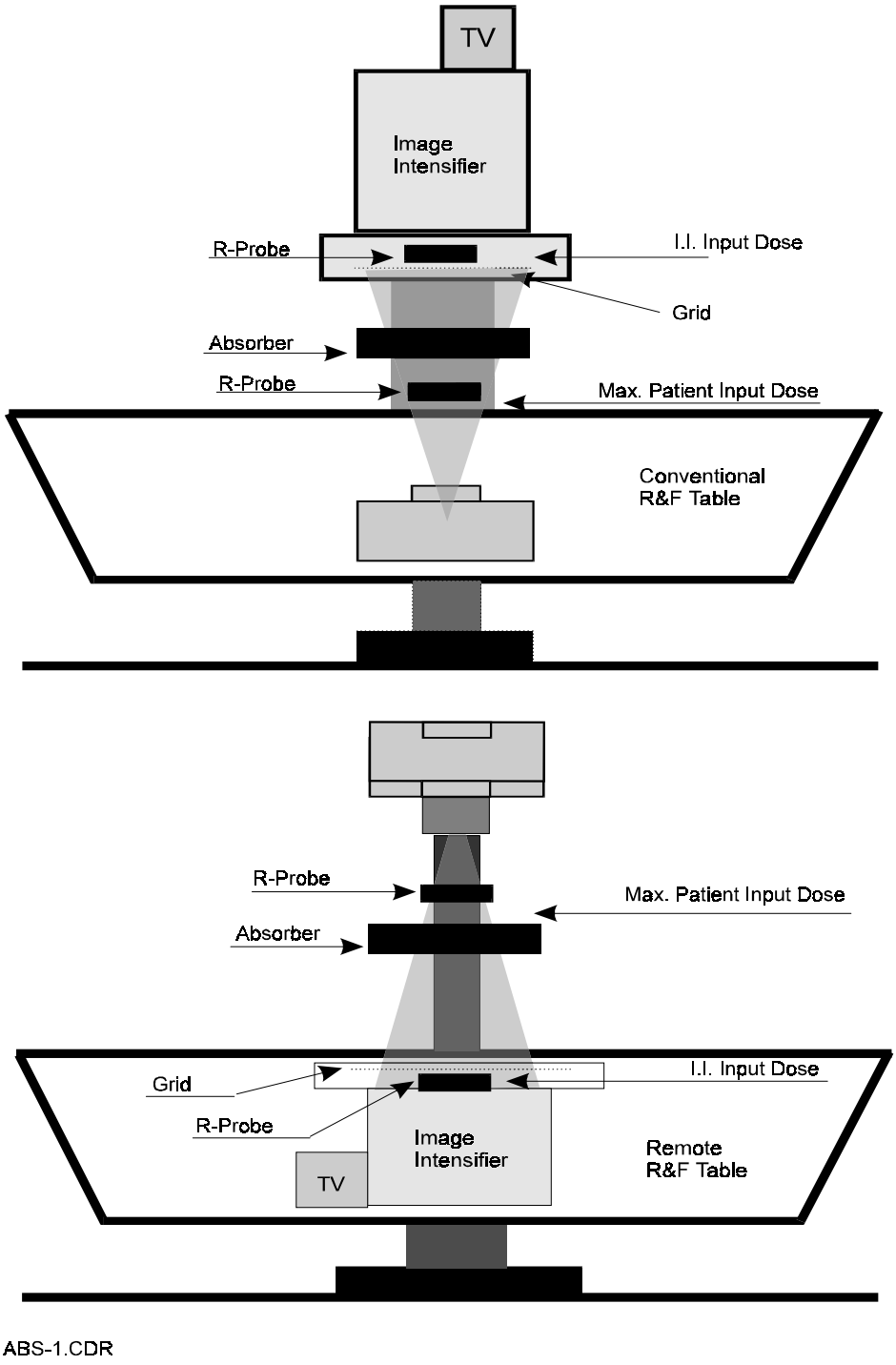


Figure 3E-5: Dose limits test setup

3E.3.1 Dose Limits (Cont)

```
                    * GENERATOR SETUP *
UTILITY                          APR EDITOR: DISABLED
                                   GEN CONFIGURATION
                                               DATA LINK
EXIT SETUP
```

```
                    * GEN CONFIGURATION *
TUBE SELECTION                                AEC SETUP
GENERATOR LIMITS                          AEC CALIBRATION
RECEPTOR SETUP                              FLUORO SETUP
I/O CONFIGURATION                        TUBE CALIBRATION
          EXIT
```

```
 TUBE1      0%HU      FLUORO SETUP*                MAG:0
DOSE LIMITS                                  I/I MODES:  2
ABS SETUP                                FL-RAD KV XFER:  6
MIN FLUORO KV:   50                                    +
                                                       -
          EXIT                                >>   DOSE:0
```

```
 TUBE1      0%HU      *ABS SETUP*                  MAG:0
LOOP GAIN      60                    AUTO MA/KV CURVE:  0
NOMINAL DOSE      80                      ABS CHANNEL:  5
DOSE 1:    100                                         +
DOSE 2:    100                                         -
          <<                                     DOSE:0
```

Use these steps to set the **DOSE LIMITS**.

Step	Action
1.	Set up the radiation probe as per figure 3E-5 in the position indicated **Max. Patient Input Dose.** Refer to the note on page 10 re focal spot to radiation probe distance. No absorber is required at this point in the setup.
2.	Temporarily unplug the ABS pickup at J7 or J8 of the generator interface board.
3.	Temporarily de-energize the I.I. power supply, or cover the I.I. with approximately 1/16″ (1.6 mm) lead.
4.	Enter into the generator programming mode. Refer to chapter 3C, section 3C.1.1.
5.	From the **GENERATOR SETUP** menu select **GEN CONFIGURATION**.
6.	From the **GEN CONFIGURATION** menu select **FLUORO SETUP.**
7.	Select **ABS SETUP.** Select **AUTO MA/KV CURVE**, then use the **+** or **-** buttons to select auto mA/kV curve **1.**
8.	Select **<<** to return to the **FLUORO SETUP** menu.

3E.3.1 Dose Limits (Cont)

TUBE1	0%HU	DOSE LIM. - ABS*			MAG:0
1.0 MA:	125KV			5.0 MA:	125KV
2.0 MA:	125KV			6.0 MA:	125KV
3.0 MA:	125KV				+
4.0 MA:	125KV				-
	<<		>>	DOSE:0	

TUBE1	0%HU	DOSE LIM. - MAN*			MAG:0
1.0 MA:	125KV			5.0 MA:	125KV
2.0 MA:	125KV			6.0 MA:	125KV
3.0 MA:	125KV				+
4.0 MA:	125KV				-
	<<		RETURDOSE:0		

IT IS RECOMMENDED THAT COPIES BE MADE OF ALL PAGES WHERE RESULTS ARE TO BE RECORDED. THE RESULTS SHOULD THEN BE RECORDED ON THE COPIES, LEAVING THE ORIGINALS BLANK.

Step	Action	Result
1.	Record the maximum permissible input dose values for ABS and non-ABS (manual) modes of fluoroscopy as per local regulations.	Maximum permitted input dose: ABS mode:_____ R/Min Non ABS mode:_____ R/Min
2.	From the **FLUORO SETUP** menu, select **DOSE LIMITS.**	The **DOSE LIM. - ABS** menu will be displayed.
3.	From the **DOSE LIM - ABS** menu, select **>>.**	The **DOSE LIM. - MAN** menu will be displayed.
4.	Ensure that the ABS function is switched OFF. The **ABS** button is located at the bottom of the FLUOROSCOPY section of the console.	The LED adjacent to the **ABS** button will be off.
5.	Set the default kV for each mA station in the **DOSE LIM - MAN** menu to the maximum permissible value (110 or 125 kV) as per local regulations.	
6.	Select the **6.0 MA** dose limit step in the LCD display window. Enter the value 6.0 mA in the fluoro control section of the console.	
7.	While observing the dosimeter, make a fluoroscopy exposure. Adjust the kV via the fluoro section of the console such that the maximum permitted dose as recorded in step 1 for ABS mode is not exceeded.	

3E.3.1 Dose Limits (Cont)

8.	Record the kV value as determined in step 7 for the 6.0 mA step.	Max kV limit for 6.0 mA = _____(ABS)
9.	Repeat steps 6 to 8 for **5.0** mA.	Max kV limit for 5.0 mA = _____(ABS)
10.	Repeat steps 6 to 8 for **4.0** mA.	Max kV limit for 4.0 mA = _____(ABS)
11.	Repeat steps 6 to 8 for **3.0** mA.	Max kV limit for 3.0 mA = _____(ABS)
12.	Repeat steps 6 to 8 for **2.0** mA.	Max kV limit for 2.0 mA = _____(ABS)
13.	Repeat steps 6 to 8 for **1.0** mA.	Max kV limit for 1.0 mA = _____(ABS)

The following steps set up the non-ABS kV limits (manual mode).

Step	Action	Result
1.	Reselect the **6.0 MA** dose limit step in the LCD display window. Enter the value 6.0 mA in the fluoro control section of the console.	
2.	While observing the dosimeter, make a fluoroscopy exposure. Adjust the kV via the fluoro section of the console such that the maximum permitted dose as recorded in step 1 (page 13) for non-ABS mode is not exceeded.	
3.	Record the kV value as determined in step 2 for the **6.0** mA step.	Max kV limit for 6.0 mA = _____(MAN)
4.	Repeat steps 1 to 3 for **5.0** mA.	Max kV limit for 5.0 mA = _____(MAN
5.	Repeat steps 1 to 3 for **4.0** mA.	Max kV limit for 4.0 mA = _____(MAN
6.	Repeat steps 1 to 3 for **3.0** mA.	Max kV limit for 3.0 mA = _____(MAN
7.	Repeat steps 1 to 3 for **2.0** mA.	Max kV limit for 2.0 mA = _____(MAN
8.	Repeat steps 1 to 3 for **1.0** mA.	Max kV limit for 1.0 mA = _____(MAN)
9.	Enter the kV limit for non-ABS mode as recorded in step 3 above (for the 6.0 mA station) into the 6.0 mA dose limit step in the LCD display. Select the 6.0 mA step in the **DOSE LIM - MAN** menu, then enter the required kV value using the **+** or **-** buttons adjacent to the LCD display.	
10.	Repeat step 9 for the **5.0** mA to **1.0** mA stations (non-ABS kV limits).	

3E.3.1 Dose Limits (Cont)

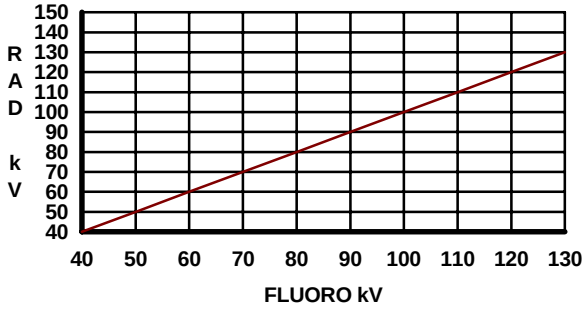
11.	Select **<<** to return to the **DOSE LIM-ABS** menu.	
12.	Enter the kV limit for ABS mode as recorded in step 8 (page 14) for the 6.0 mA station into the 6.0 mA dose limit step in the the LCD display. Select the 6.0 mA step in the **DOSE LIM - ABS** menu, then enter the required kV value using the **+** or **-** buttons adjacent to the LCD display.	
13.	Repeat step 12 for the **5.0** to **1.0** mA stations (ABS kV limits)..	
14.	Select **<<** to return to the **FLUORO SETUP** menu.	

3E.3.2 ABS Defaults

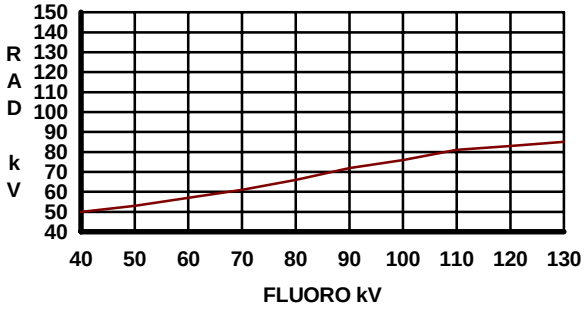
Step	Action
1.	From the **FLUORO SETUP** menu select **MIN FLUORO KV.** Press the **+** or **-** buttons to select the minimum kV to be allowed in fluoro.
2.	Select **I/I MODES.** Press the **+** or **-** buttons to select the number of mag modes in the I.I. (2 corresponds to 2 mag modes plus normal mode).
3.	Select **FL-RAD KV XFER.** Press the **+** or **-** buttons to select the desired fluoro-rad kV transfer curve. This allows selection of one-of-six fluoro to rad kV transfer curves. When in fluoro operation with ABS on, the fluoro kV value is transferred to the RADIOGRAPHY section of the console at the end of the fluoro exposure. This presets the rad kV in preparation for a rapid follow-on radiographic exposure for digital acquisition or spot film work. Graphs of the fluoro kV to rad kV transfer function are shown following this step. Selecting **0** disables this function.

3E.3.2 ABS Defaults (Cont)

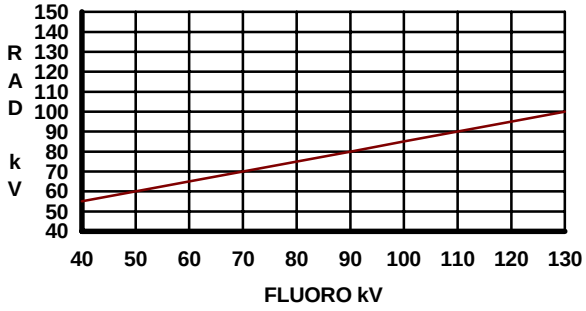
Curve 1



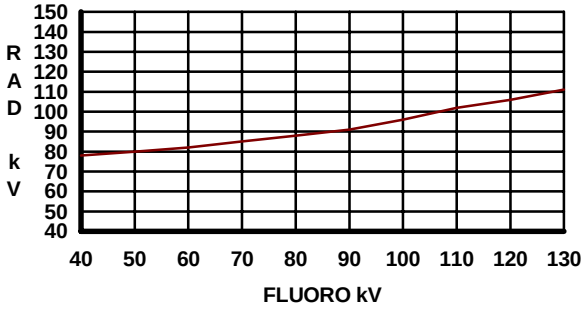
Curve 2



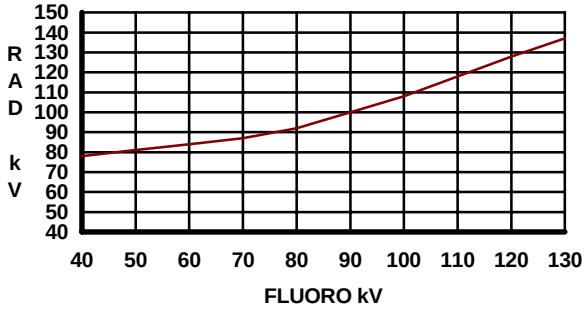
Curve 3



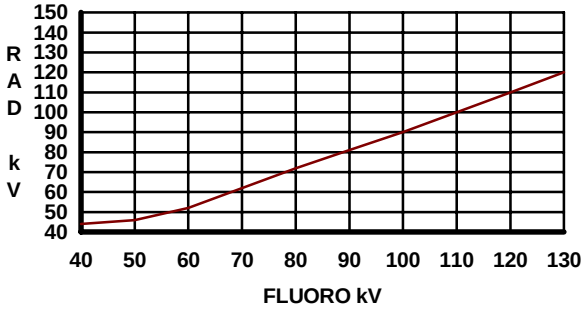
Curve 4



Curve 5



Curve 6



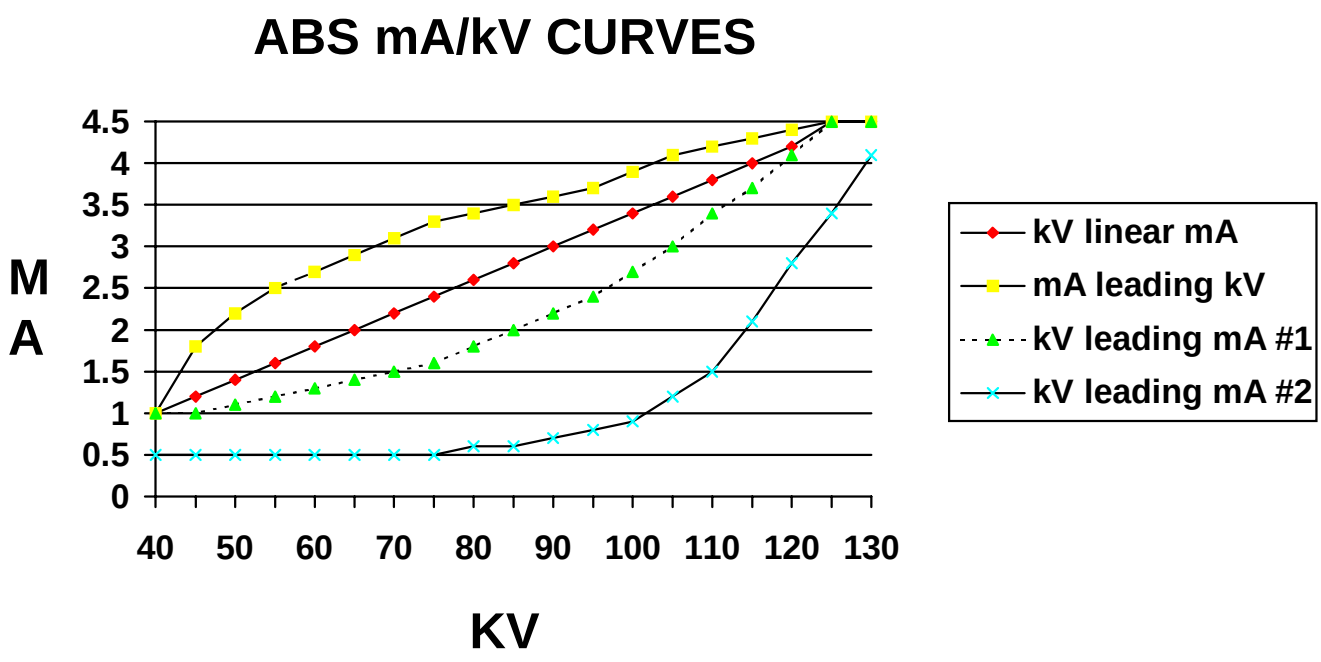
3E.3.2 ABS Defaults (Cont)

```
 TUBE1        0%HU        FLUORO SETUP*                    MAG:0
ABS DEFAULT:   OFF
FL  TIMER MODE: 10MIN



          <<                                              DOSE:0
```

Step	Action
1.	From the **FLUORO SETUP** menu select **>>.** The above menu will display.
2.	Select **ABS DEFAULT.** Toggle to select **NONE, OFF,** or **ABS.** **NONE:** No default selected, ABS remains at its last setting. **OFF:** Defaults to ABS OFF. **ABS:** Defaults to ABS ON.
3.	Select **FL TIMER MODE.** Toggle to select **5MIN** or **10MIN**. **5MIN:** Alarms at 5.0 minutes, and stops incrementing the timer. Fluoro exposures will continue. **10MIN:** Alarms at 5.0 minutes, stops incrementing the timer at 9.6 minutes. Fluoro exposures will be inhibited at 9.6 minutes.
4.	Select **<<** to return to the **FLUORO SETUP** menu.
5.	Select **ABS SETUP.** The **ABS SETUP** menu will display as shown below.
6.	Select **ABS CHANNEL**. This selects the hardware ABS input. This must be set to **5.**
7.	Select **AUTO MA/KV CURVE.** Press the **+** or **-** buttons to select the desired fluoro mA/kV curve. This sets how the kV and mA change during ABS operation. **0:** Changes kV only (mA set manually). **1:** kV linear mA. **2:** mA leading kV. **3:** kV leading mA #1. **4:** kV leading mA #2 (reduced dose). Refer to the graph of these curves as shown on the next page.

```
 TUBE1        0%HU        *ABS SETUP*                      MAG:0
LOOP GAIN         60                        AUTO MA/KV CURVE:  0
NOMINAL DOSE      80                             ABS CHANNEL:  5
DOSE 1:    100                                                 +
DOSE 2:    100                                                 -
          <<                                              DOSE:0
```

3E.3.2 ABS Defaults (Cont)



3E.3.3 I.I. Input Dose Calibration

This procedure sets the actual operating input dose to the I.I. Please note the following:

- Ensure that the collimator is adjusted to only expose the I.I. input.
- The central ray from the X-ray tube must coincide with the center of the I.I.
- The required I.I. input dose must be known before proceeding. Typical values (for reference only) are:
  - ⇒ 6 inch (15 cm) I.I. = 8.1 mR/min.
  - ⇒ 9 inch (23 cm) I.I. = 3.6 mR/min.
  - ⇒ 12 inch (30 cm) I.I = 2.0 mR/min

3E.3.3 I.I. Input Dose Calibration (Cont)

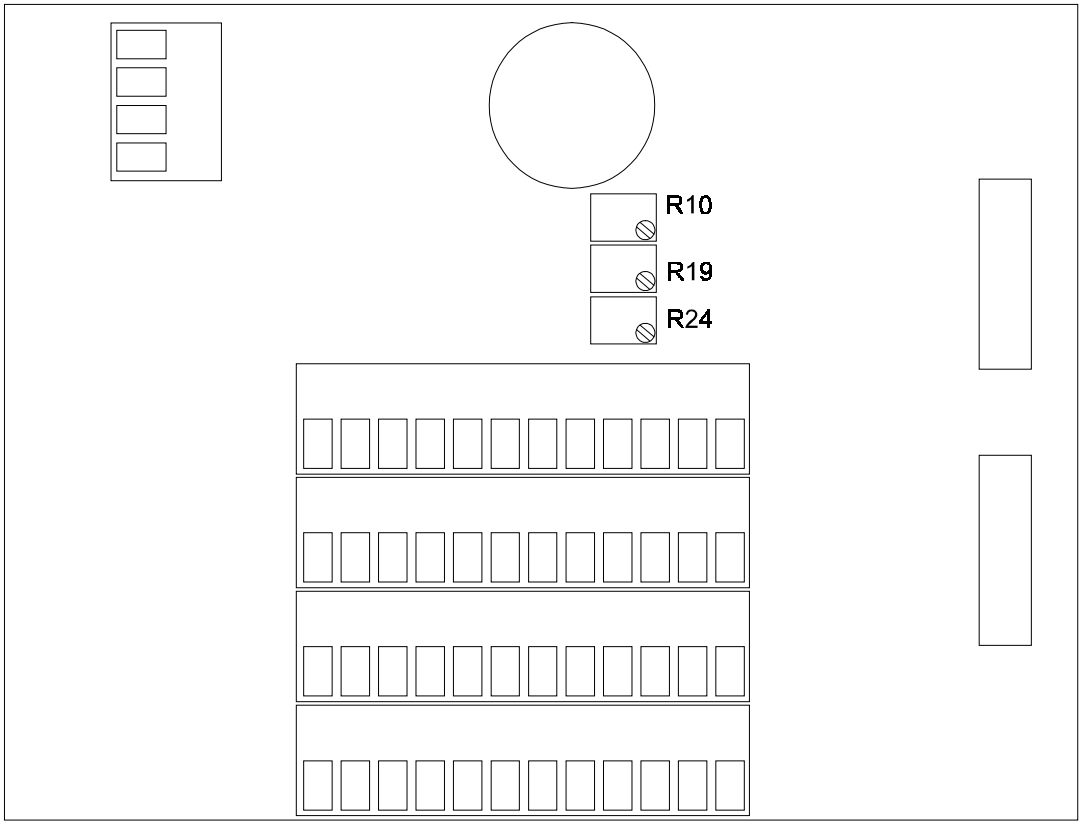


Figure 3E-6: PMT high voltage adjustment (AEC interface board)

- R10 adjusts the PMT high voltage during ABS operation. Refer to 3E.3.3.
- R19 and R24 adjust the ion chamber bias voltage and PMT high voltage during AEC operation. Refer to chapter 3D for further details.

3E.3.3 I.I. Input Dose Calibration (Cont)

Use these steps to set the input dose to the I.I.

Step	Action
1.	Reconnect the ABS pickup plug that was temporarily disconnected from J7 or J8 of the generator interface board in an earlier step.
2.	Re-energize the I.I. power supply or remove the lead that was temporarily installed in an earlier step.
3.	Set up the radiation probe as per figure 3E-5 in the position indicated **I.I. Input Dose.** This must be able to read dose values as low as 2 to 3 mR/min.
4.	Set up the absorber as shown in the above figure. 1 1/2" (40mm) of aluminum is recommended, refer to table 3E-1 if aluminum is unavailable. Ensure that the absorber covers the full input field of the I.I.
5.	Select 75kV and 1.5 mA. Ensure that the ABS is off.
6.	Ensure that the I.I. is in the NORMAL mode (MAG = 0). Ensure that an anti-scatter grid, if used, is properly installed.
7.	Make a fluoro exposure and measure the I.I. input dose.
8.	Adjust the fluoro kV to achieve the desired input dose.
9.	Connect a DVM or 'scope to TP8 and ground of the generator interface board.
10.	Adjust **R48** on the generator interface board to achieve 2.0 VDC at the test points connected to in the previous step.
11.	From the **ABS SETUP** menu, select **LOOP GAIN.** Press the **+** or **-** buttons to select the initial value of **25.** This controls the speed at which the ABS corrects the dose. Fast pickups such as a PMT will typically require a value of 25 to 40, slower pickups such as video or proportional DC will require a higher value. This is initially set to 25, and may need to be readjusted to prevent slow response or instability when operating in ABS mode.
	ENSURE THAT THE DOSE IS SET TO 0 ON THE CONSOLE.
12.	From the **ABS SETUP** menu, select **NOMINAL DOSE.** Press the **+** or **-** buttons to select a value of 200.
13.	Switch the **ABS** ON. The LED adjacent to the **ABS** switch at the bottom of the FLUOROSCOPY section of the console will light.
	NOTE: STEPS 14 TO 16 APPLY ONLY IF USING A PMT. IGNORE THESE STEPS FOR OTHER ABS PICKUP DEVICES **WARNING: SWITCH OFF THE GENERATOR AND ENSURE THAT ALL CAPACITORS ARE DISCHARGED BEFORE MAKING AND REMOVING THE PMT CURRENT MEASURING EQUIPMENT**
14.	Connect a microammeter in series with the PMT signal output. Alternately, if a microammeter is not available, follow this procedure: • Temporarily connect a resistor of known value (100K is suggested) from either end of R61 on the generator interface board to ground. A DVM can then be used to measure the voltage developed by the PMT current across this resistor. However, this is not the preferred method of measurement.

3E.3.3 I.I. Input Dose Calibration (Cont)

15.	Adjust the PMT high voltage using **R10** (refer to figure 3E-6) on the AEC interface board while pressing the fluoro footswitch such that the PMT current is 20 ± 5 uA at the desired I.I. input dose. This corresponds to a voltage of 2.00 ± 0.50 VDC for a 100K resistor if using the voltmeter method in the above step. The high voltage should be approximately -750 VDC at this point. *The PMT high voltage is adjusted to yield the PMT **current** noted in this step. The approximate value of PMT voltage is stated for reference only. The PMT voltage does not normally need to be measured in this step, however, if it is desired to do so for troubleshooting purposes please note the following:* ***USE TP5 ONLY ON THE AEC INTERFACE BOARD FOR THE HV METER GROUND WHEN MEASURING PMT HIGH VOLTAGE. CONNECT THE GROUND FIRST BEFORE MEASURING THE HIGH VOLTAGE.*** **DO NOT ATTEMPT TO MEASURE THIS WITHOUT A SUITABLE METER.**
16.	Disconnect the meter (and resistor if applicable) that was was connected in step 9. Reconnect the PMT signal lead if required.
17.	Initiate fluoro operation and measure the input dose to the I.I. If this value is not as desired adjust the **NOMINAL DOSE** using the **+** or **-** buttons as required. Record this value in step 1 of 3E.3.4.

3E.3.4 Dose1/Dose2 Calibration

Use these steps to calibrate dose 1 and dose 2.

Step	Action	Result
1.	Before continuing, record the **NOMINAL DOSE** value as determined in the previous section.	Nominal Dose (cal value): _____
2.	Record the desired dose 1 and dose 2 input values.	Desired dose values: Dose 1:_____ mR/Min Dose 2:_____ mR/Min
3.	Initiate fluoro operation and measure the input dose to the I.I. Adjust to the desired dose 1 value by altering the **NOMINAL DOSE** value as required using the **+** or **-** buttons.	
4.	When the desired dose 1 value has been achieved, enter the new NOMINAL DOSE value in the **DOSE 1** location using the **+** or **-** buttons.	
5.	Initiate fluoro operation and measure the input dose to the I.I. Adjust to the desired dose 2 value by altering the **NOMINAL DOSE** value as required using the **+** or **-** buttons.	
6.	When the desired dose 2 value has been achieved, enter the new NOMINAL DOSE value in the **DOSE 2** location using the **+** or **-** buttons.	

3E.3.4 Dose1/Dose2 Calibration (Cont)

7.	Reset the original NOMINAL DOSE value by entering the value recorded in step 1 of this table into the **NOMINAL DOSE** location using the **+** or **-** buttons.	
8.	Verify each dose (nominal, dose 1, and dose 2) by initiating fluoro operation and measuring the I.I. input dose.	
9.	Press **<<**, then **EXIT** to exit out of FLUORO SETUP mode. Press **EXIT**, then **EXIT SETUP** to return to the normal operating mode. This completes the fluoro calibration.	

CHAPTER 4

ACCEPTANCE TESTING

CONTENTS:

4.1.0 INTRODUCTION

This section details acceptance testing, which verifies that the generator is performing within limits. It is recommended that this be done whenever the generator is reconfigured, or component(s) are replaced which may affect the X-ray output. Examples of such components are the X-ray tube, HT tank, generator CPU board, generator interface board, AEC board, control board 1 and control board 2 in the HF power supply, and the filament supply board(s).

WARNING:
1. ***USE EXTREME CARE IN MEASURING HIGH VOLTAGES. ACCIDENTAL CONTACT MAY CAUSE INJURY OR DEATH.***
2. ***EVEN WITH THE GENERATOR SWITCHED OFF AT THE CONSOLE, (OR THE LOCKOUT SWITCH INSIDE THE MAIN CABINET LOCKED OUT), MAINS VOLTAGE IS STILL PRESENT INSIDE THE GENERATOR CABINET. THIS VOLTAGE IS EXTREMELY DANGEROUS, USE EXTREME CAUTION.***
3. ***THE ELECTROLYTIC CAPACITORS, LOCATED ON THE BASE OF THE HF POWER SUPPLY, PRESENT A HAZARD FOR A MINIMUM OF 5 MINUTES AFTER THE POWER HAS BEEN SWITCHED OFF. VERIFY THAT THESE CAPACITORS ARE DISCHARGED BEFORE SERVICING OR TOUCHING ANY PARTS.***

WARNING: ***THE PROCEDURES IN THIS CHAPTER REQUIRE THE PRODUCTION OF X-RAYS. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

WARNING:
1. ***ALWAYS ENSURE THAT THE EQUIPMENT UNDER TEST AND ALL ASSOCIATED TEST EQUIPMENT IS PROPERLY GROUNDED***
2. ***ENSURE THAT THE HIGH VOLTAGE CABLES ARE INTACT/UNDAMAGED AND PROPERLY CONNECTED BEFORE ATTEMPTING EXPOSURES***

ENSURE THAT THE FOLLOWING ITEMS ARE COMPLETED PRIOR TO PERFORMING THE ACCEPTANCE TESTING:

- The generator is interfaced to room equipment noted in the product description.
- The tube auto calibration has been done as per chapter 2 of this manual.
- The receptors have been programmed as per chapter 3C of this manual.
- If the installation has AEC; verify that all receptors have been calibrated as per chapter 3D of this manual.
- If the installation has ABS; verify that the imaging system has been calibrated as per chapter 3E of this manual.
- Acceptance testing shall only be started after the installation is complete i.e.; generator in final position and installed as per chapter 1C.

4.2.0 REQUIRED TEST EQUIPMENT FOR GENERATOR VERIFICATION.

- KV measuring device such as a dynalyzer (or equivalent). This will be required for verifying kV and mA calibration during preventative maintenance or if recalibration is necessary, for example after replacing the generator CPU board or control board 1 in the HF power supply. See note on page 11 regarding use of a Dynalyzer on Indico 100 generators.
- Storage oscilloscope.
- mA/mAs meter.
- Radiation meter 0-1000 mR and 1-15 R/min.
- Lead diaphragm or equivalent to collimate the beam.
- General purpose DVM.
- Strobe or reed tachometer.
- Current probe 0 to 20 amps AC.
- A set of HVL filters.
- Calculator

4.3.0 CONSOLE OVERVIEW

Figure 4-1 shows the designations of the membrane switches for the 23 X 56 (cm) console and for the 13 X 42 (cm) console as referenced in the acceptance test procedure.

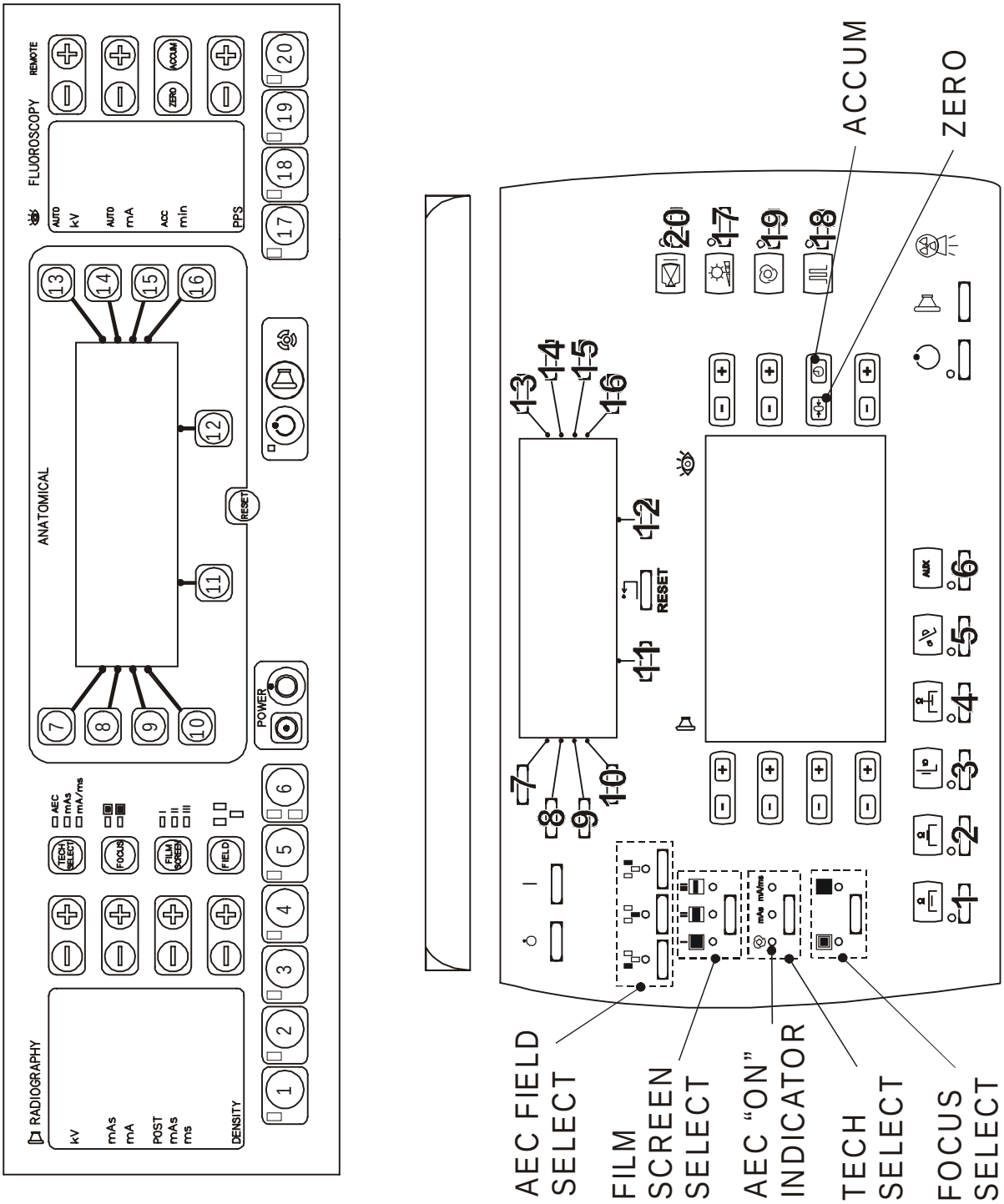


Figure 4-1: Console switch designations

4.4.0 ACCEPTANCE TESTS (BASIC FUNCTIONS)

Refer to figure 4-1 for switch designations **1** to **20** in the following steps.

4.4.1 Console Rad Tests

Step	Action	Result	Check
1.	Press power ON then power OFF buttons on console.	Unit switches on and off.	
2.	Press power ON again to switch unit on.	Unit switches on.	
3.	Press each of the receptor buttons **1** to **6** that are active (those that have been enabled during generator configuration).	Verify that the adjacent LED lights for each receptor. For receptor **6** only the top LED will light (23 X 56 cm console).	
NOTE: THE **TECH SELECT** BUTTON IN STEPS 4, 5, 6 WILL ONLY BE FUNCTIONAL IF APR MODE HAS BEEN DISABLED DURING GENERATOR CONFIGURATION (**TECH SELECT** IS DISABLED IF APR MODE ENABLED).			
4.	Select an active radiographic receptor that has AEC programmed. Press **TECH SELECT** to select **AEC** Verify the following displays:	A: **AEC** LED lights. B: kV value displayed. C: mA value displayed. D: "AEC", mAs value or ms value displayed depending on AEC backup mode selected. E: density value displayed.	
5.	Press **TECH SELECT** to select **mAs** Verify the following displays:	A: **mAs** LED lights. B: kV value displayed. C: mAs value displayed.	
6.	Press **TECH SELECT** to select **mA/ms** Verify the following displays:	A: **mA/ms** LED lights. B: kV value displayed. C: mA value displayed. D: ms value displayed.	
7.	Press the kV **+/-** buttons.	kV increases if kV **+** pressed. kV decreases if kV **-** pressed.	
8.	Ensure that three point operation is selected (**mA/ms)**. Press the mA **+/-** buttons.	mA increases if mA **+** pressed. mA decreases if mA **-** pressed.	
9.	Ensure that three point operation is selected (**mA/ms)**. Press the ms **+/-** buttons.	ms increases if ms **+** pressed. ms decreases if ms **-** pressed.	
10.	Ensure that **AEC** is selected. Press the DENSITY **+/-** buttons.	Density increases if density **+** pressed. Density decreases if density **-** pressed.	
11.	Press the **FOCUS** button.	Large and small focal spot LED's alternately light as the switch is toggled.	
12.	Ensure that **AEC** is selected. Press the **FILM SCREEN** button.	The three film screen LED's (I, II, III) alternately light as the switch is toggled.	
13.	Press the PREP button.	The adjacent LED lights.	
14.	Press the X-ray button. Select 60 kV, 50 mA, 100 ms for this exposure.	The X-ray warning indicator lights during an X-ray exposure, and an audible tone is heard from the console.	

4.4.1 Console Rad Tests (Cont)

Step	Action	Result	Check
14.	Ensure that **AEC** is selected. Press the **FIELD** button (23 X 56 cm console) or press the individual AEC field select buttons in sequence (31 X 42 cm console).	The three field indicator LED's light to indicate field selection [L+C+R], [R], [C], [R+C], [L], [L+R], [L+C] as the switch is toggled (23 X 56 cm console). For the 31 X 42 cm console, the left, center, right field selection LED's should light as each field is selected.	
15.	Press power OFF button on console.	Unit switches off.	

4.4.2 Console Fluoro Tests

This section applies only to R&F units.

BEFORE CONTINUING, ENSURE THAT THE REMOTE FLUORO CONTROL IS CONNECTED (IF USED WITH THIS INSTALLATION).

Step	Action	Result	Check
1.	Press power ON button on console.	Unit switches on.	
2.	Select an active fluoro receptor **1** to **6**.	A: Fluoro display area of console lights. B: Remote fluoro control panel lights (if used).	
3.	Press the DOSE button **17**.	Dose display on LCD display changes as switch is toggled.	
4.	Press the MAG button **20** on the console. Press the MAG **+/-** buttons on the remote fluoro control if used.	A: Mag display on console LCD and remote fluoro display changes (IF I/I MODES ENABLED DURING GENERATOR CONFIGURATION) as switch **20** is toggled. B: Mag display on console LCD and remote fluoro display increases if MAG **+** button is pressed, decreases if MAG **-** button on the remote fluoro control is pressed (IF I/I MODES ENABLED DURING GENERATOR CONFIGURATION.	
5.	Press the ABS button **19** on the Console to enter ABS mode.	A: The LED adjacent to button **19** lights. B: The LED adjacent to the **ABS** button on the remote fluoro control if used lights.	
6.	Press the **ABS** button on the remote fluoro control if used, else press ABS button **19** on the console.	ABS indicator LED's adjacent to ABS buttons on console and remote fluoro control if used are off.	

4.4.2 Console Fluoro Tests (Cont)

Step	Action	Result	Check
7.	Press the fluoro kV **+/-** buttons on the console and remote fluoro control if used.	KV increases if kv **+** pressed. KV decreases if kv **-** pressed. Confirm tracking of kV displays on console and remote fluoro control.	
8.	Press the fluoro mA **+/-** buttons on the console and remote fluoro control if used.	MA increases if mA **+** pressed. MA decreases if mA **-** pressed. Confirm tracking of mA displays on console and remote fluoro control.	
9.	Press **ACCUM** button on console.	**ACC** indicator will light/extinguish on console as the switch is toggled.	
10.	Press **ACCUM** button on remote fluoro control if used.	**ACC** indicator will light/extinguish on remote fluoro control as the switch is toggled.	
11.	Press the pulse fluoro button **18** on the console (if pulse fluoro option is fitted).	The pulse fluoro indicator will light/extinguish as the switch is toggled.	
12.	Press power OFF button on console.	Unit switches off.	

4.4.3 Generator Preliminary Tests

WARNING: ***USE EXTREME CAUTION WHEN MEASURING HIGH VOLTAGES.***

NOTE: ***VERIFY THE POSITION OF EACH OF THE SWITCHES OF SW1 ON THE GENERATOR CPU BOARD FOR THE GENERATOR UNDER TEST AS PER THE TABLE BELOW. THESE SWITCHES MUST BE SET CORRECTLY PRIOR TO CONTINUING. REFER TO THE PRODUCT DESCRIPTION (SECTION 1D) AS NECESSARY FOR PRODUCT DEFINITION.***

For GENERATOR POWER, refer to copy of the product description (PD) form in Chapter 1D			
GENERATOR POWER	**SW1-3**	**SW1-2**	**SW1-1**
30 kW (350 Series)	ON	ON	OFF
37.5 kW (***Indico 100 only***)	ON	OFF	ON
50 kW (650 Series)	OFF	ON	ON
65 kW (850 Series)	OFF	ON	OFF
80 kW (1050 Seies)	OFF	OFF	ON
SW1-4: OFF for two filament boards, ON for one filament board.			
SW1-5: OFF for 150 max kV, ON for 125 max kV. Refer to PD near top of page 2.			
SW1-6: OFF for dual speed, ON for low speed. Refer to PD near top of page 3.			
SW1-7: OFF for 2 tube, ON for 1 tube. Refer to PD near top of page 3.			
SW1-8: ON. It is strongly suggested this switch not inadvertently be set to OFF! Setting to OFF resets to factory defaults (calibration, configuration, etc)			

4.4.3 Generator Preliminary Tests (Cont)

Step	Action	Result	Check
1.	Ensure unit switched OFF.	DS1 on generator interface board lit.	
2.	Press power ON button on console.	One or more LED's on driver/auxiliary board in HF power supply are lit. *This step does not apply to Indico 100 generators.*	
3.	Switch OFF console. Switch NORMAL/LOCKOUT switch on generator interface board to **LOCKOUT**. Switch console ON.	Generator will not switch on with switch in lockout position.	
4.	Switch NORMAL/LOCKOUT switch to **NORMAL** position. Switch Console ON.	Unit switches on.	
5.	Verify that each active receptor (those that have been enabled during generator configuration) displays the desired X-ray tube on the LCD display.	Receptor 1 Tube # _____ Receptor 2 Tube # _____ Receptor 3 Tube # _____ Receptor 4 Tube # _____ Receptor 5 Tube # _____ Receptor 6 Tube # _____	
6.	Verify that each active receptor selects the desired AEC channel. This must be done by measuring the voltage at specified pins on the AEC board edge connector. Logic low (approx. 1 VDC) means CHANNEL ENABLED, logic high (approx. 11.5 VDC) means CHANNEL DISABLED. Refer to figure 4-2 for pin assignments on the AEC board: CHANNEL 1 = PIN 8 CHANNEL 2 = PIN 7 CHANNEL 3 = PIN 6 CHANNEL 4 = PIN 5	Receptor 1 Ch # _____ Receptor 2 Ch # _____ Receptor 3 Ch # _____ Receptor 4 Ch # _____ Receptor 5 Ch # _____ Receptor 6 Ch # _____	
7.	Switch OFF the console.	N/A	

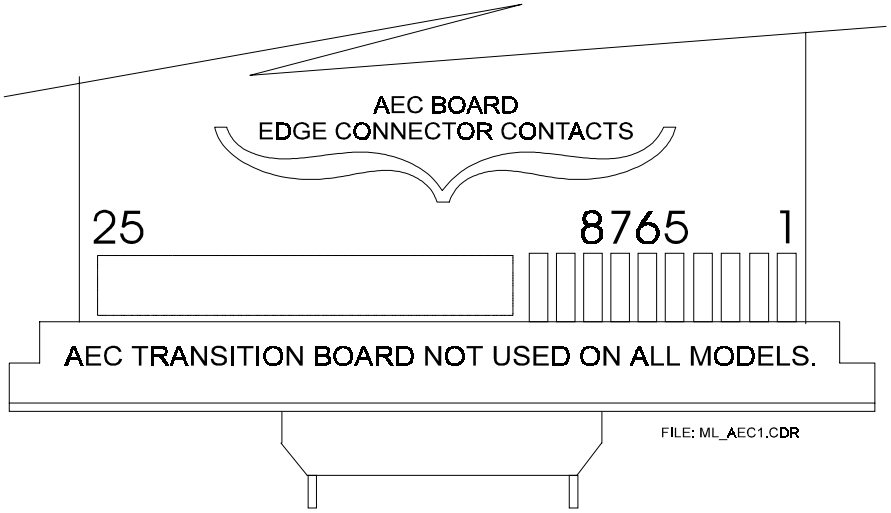


Figure 4-2: AEC board pin assignments

THE MILLENIA AND INDICO 100 FAMILY OF GENERATORS IS FITTED WITH A LOW SPEED STARTER, OR OPTIONAL DUAL SPEED STARTER. USE SECTION 4.4.4 OR 4.4.5 AS APPLICABLE FOR YOUR GENERATOR.

4.4.4 Low Speed Starter Verification

Step	Action	Result	Check
1.	Connect a current probe to the common lead of tube 1. Switch ON the console. Press and hold the "PREP" button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
2.	Measure the rotor boost time.	Should be approximately 1.5 sec.	
3.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost.	Speed ≥ 3300 RPM.	
FOLLOW STEPS 4 TO 6 IF TUBE 2 IS USED (LOW SPEED STARTER)			
4.	Connect a current probe to the common lead of tube 2. Press and hold the "PREP" button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
5.	Measure the rotor boost time.	Should be approximately 1.5 sec.	
6.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost.	Speed ≥ 3300 RPM.	
7.	Switch OFF the console.	N/A	

4.4.5 Dual Speed Starter Verification

From the product description, be sure the actual tube being used is correctly selected at the dual speed starter. Review chapter 2, table 2-1 (tube select table).

Tube 1 selection verified _____
Tube 2 selection verified _____

THE GENERATOR MUST BE PROGRAMMED FOR DUAL SPEED STARTER OPERATION IN ORDER TO BE ABLE TO VERIFY BOTH MODES OF OPERATION IN THIS SECTION.

******* PLEASE OBSERVE A MAXIMUM OF 2 HIGH SPEED BOOSTS PER MINUTE *******

Step	Action	Result	Check
1.	Connect a current probe to the common lead of tube 1. Switch ON the console. Select 70 kVp, minimum mA, 50 mSec. Press and hold the "PREP" button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
2.	Measure the rotor boost time.	Should agree with value in chapter 2, table 2-1.	
3.	Select 100 kVp, maximum mA, 50 ms, small focus. Press and hold the "PREP" button.	A 180 Hz waveform dropping to less than half amplitude after prep complete.	

4.4.5 Dual Speed Starter Verification (Cont)

Step	Action	Result	Check
4.	Measure the rotor boost time.	Should agree with value in table 2-1.	
5.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost. Use the techniques in steps 1 and 3 to select low and high speed modes respectively.	Low Speed ≥ 3300 RPM. High Speed ≥ 9500 RPM.	
6.	After a high speed prep, verify that the dynamic brake is applied.	Will hear the X-ray tube slow down to 60 Hz.	
FOLLOW STEPS 7 TO 12 IF TUBE 2 IS USED (DUAL SPEED STARTER)			
7.	Connect a current probe to the common lead of tube 2. Select 70 kVp, minimum mA, 50 mSec. Press and hold the “PREP” button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
8.	Measure the rotor boost time.	Should agree with value in table 2-1.	
9.	Select 100 kVp, maximum mA , 50 ms, small focus. Press and hold the “PREP” button.	A 180 Hz waveform dropping to less than half amplitude after prep complete.	
10.	Measure the rotor boost time.	Should agree with value in table 2-1.	
11.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost. Use the techniques in steps 7 and 9 to select low and high speed modes respectively.	Low Speed ≥ 3300 RPM. High Speed ≥ 9500 RPM.	
12.	After a high speed prep, verify that the dynamic brake is applied.	Will hear the X-ray tube slow down to 60 Hz.	
13.	Switch OFF the console	N/A	

4.5.0 ACCEPTANCE TESTS (KVP, TIME, MA AND MAS)

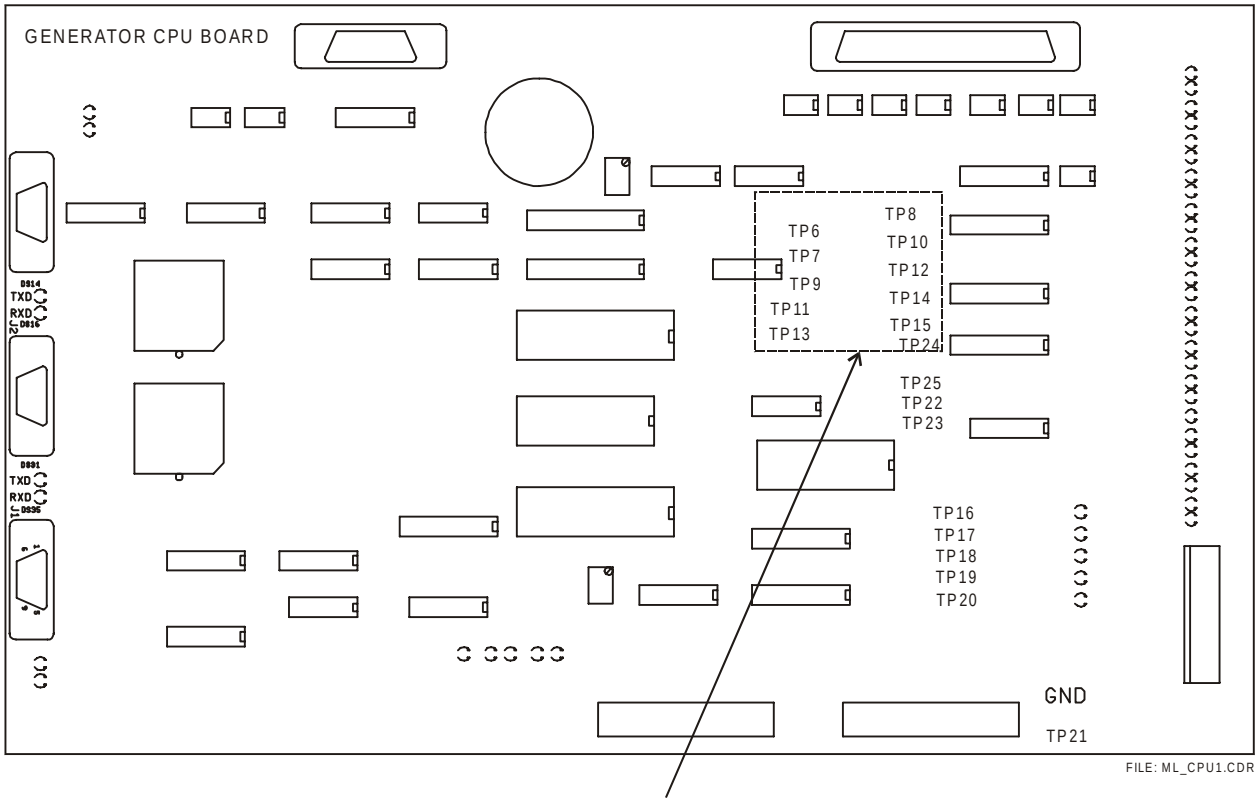
4.5.1 Generator Rad Tests

Measurement of kVp, mA, and time may be done via test points at the generator CPU board as per figure 4-3. These are direct feedback voltages and are scaled to represent the actual kVp and X-ray tube current **AS LONG AS THE GENERATOR IS CALIBRATED.**

REFER TO NOTES ON PAGE 11.

NOTE: ***TEST EQUIPMENT TOLERANCES MUST BE ALLOWED FOR IN THE MEASUREMENTS IN THE FOLLOWING SECTIONS. LIMITS STATED ARE THE MAXIMUM ALLOWED LIMITS, INCLUDING EQUIPMENT TOLERANCES AND MEASUREMENT ERROR.***

4.5.1 Generator Rad Tests (Cont)



KVP TP6 ● - + ● TP8 1VOLT = 20 KV

RAD mA TP7 ● - + ● TP10 1 VOLT = 100 mA

AEC RAMP TP9 ● - + ● TP12

FLUORO mA TP11 ● - + ● TP14 1 VOLT = 2.5 mA

TP13 ● + - ● TP15

ABS

THE SCALING FACTORS LISTED ABOVE ARE NOMINAL VALUES.

NOTE: THIS DIAGRAM IS TYPICAL, ACTUAL GENERATOR CPU BOARDS MAY DIFFER IN DETAIL

Figure 4-3: Test point locations

4.5.1 Generator Rad Tests (Cont)

CAUTION: ***THE FOLLOWING TESTS REQUIRE THE PRODUCTION OF X-RADIATION. USE APPROPRIATE SAFETY PRECAUTIONS TO PROTECT PERSONNEL.***

NOTE: ***IF USING TEST POINTS TP6 & 8, TP7 & 10, TP11 & 14 IN FIGURE 4-3 FOR ACCEPTANCE TESTING, THE SCALING FACTORS SHOWN MUST BE VERIFIED USING AN APPROPRIATE CALIBRATED REFERENCE STANDARD. THE ACTUAL MEASURED SCALING VALUES SHOULD THEN BE USED IN THIS PROCEDURE.***

NOTE: ***A DYNALYZER IS NOT RECOMMENDED FOR MA MEASUREMENTS WITH 100 KHZ INDICO 100 GENERATORS. BANDWIDTH LIMITATIONS OF THE DYNALYZER WILL RESULT IN INACCURATE MA MEASUREMENTS AT MA VALUES LESS THAN APPROXIMATELY 100 MA. MA MEASUREMENTS SHOULD BE MADE WITH AN MA/MAS METER CONNECTED TO THE MA TEST JACKS ON THE HT TANK. EXPOSURE TIMES MUST BE GREATER THAN 100 MS TO ENSURE ACCURATE MEASUREMENTS.***

Refer to figure 4-3 for test point locations referenced in the following section(s).

Step	Action	Result	Check
1.	**SEE NOTE ABOVE RE USE OF TEST POINTS FOR VERIFYING CALIBRATION** Connect 'scope probe channel 1 input to TP6 and TP8 (kVp) Connect 'scope probe channel 2 input to TP7 and TP10 (Rad mA). Adjust 'scope gains as required. Use the KV signal to trigger the 'scope.	N/A	
2.	Switch ON the generator and after initialization select the following radiographic technique: kVp = 100, mA = 100, Time = 50 ms Select an off-table receptor.	N/A	
3.	Make an exposure and measure the kVp at TP6 and TP8 and the Rad mA at TP7 and TP10. Using scaling factors in figure 4-3, verify the following results:	kVp = 100 KV ± 3%. mA = 100 mA ± 4% (Millenia). mA = 100 mA ± 5% (Indico 100). Time = 50 ms ± 2 ms.	
4.	Repeat step 3 but set the values to kVp = 65, mA = 200.	kVp = 65 KV ± 3%. mA = 200 mA ± 4% (Millenia). mA = 200 mA ± 5% (Indico 100). Time = 50 ms ± 2 ms.	

4.5.1 Generator Rad Tests (Cont)

Step	Action	Result	Check
5.	Repeat step 3 but set the values to kVp = 125, mA = 200.	kVp = 125 KV ± 3%. mA = 200 mA ± 4% (Millenia). mA = 200 mA ± 4% (Indico 100). Time = 50 ms ± 2 ms.	
6.	Select 75 kVp, 200 mA. Select the exposure times shown below (3 point operation). (Measure time and mA on the 'scope and check that their product is as per the RESULT column). Measure time at 75% of the peak kVp waveform. A: 10 ms (2 mAs) B: 20 ms (4 mAs) C: 63 ms (12 mAs) D: 100 ms (20 mAs)	 A: 2 mAs ± 5%. B: 4 mAs ± 5%. C: 12 mAs ± 5%. D: 20 mAs ± 5%.	
7.	Select 75 kVp. Select the mAs shown below (2 point operation). Measure time at 75% of the peak kVp waveform. A: 2 mAs (time per LCD display) B: 8 mAs (time per LCD display) C: 25 mAs (time per LCD display) D: 63 mAs (time per LCD display)	NOTE: The time associated with each mAs setting will vary depending on generator configuration. Use the time displayed in the LCD window as the reference for the measurements below. time per LCD disp ± (2% + 1ms). time per LCD disp ± (2% + 1ms). time per LCD disp ± (2% + 1ms). time per LCD disp ± (2% + 1ms).	
8.	Select 200 mA, 50 ms (3 point operation). Select the kVp values shown below. The measurements may be done non-invasively or from TP6 and TP8 using the 'scope. A: 50 kVp B: 60 kVp C: 80 kVp D: 100 kVp E: 125 kVp	 A: 50 kVp ± (3% + 1 kVp). B: 60 kVp ± (3% + 1 kVp). C: 80 kVp ± (3% + 1 kVp). D: 100 kVp ± (3% + 1 kVp). E: 125 kVp ± (3% + 1 kVp).	

4.5.1 Generator Rad Tests (Cont)

Step	Action	Result	Check
9.	Select 75 kVp, 50 ms (3 point operation). Select the mA values shown below. Measure mA at 75% of the peak kVp waveform. A: 50 mA B: 100 mA C: 200 mA D: 400 mA E: 800 mA Note: The higher mA values will not be available on all generator models and/or programmed tube types.	 A: 50 mA ± (5% + 1 mA). B: 100 mA ± (5% + 1 mA). C: 200 mA ± (5% + 1 mA). D: 400 mA ± (5% + 1 mA). E: 800 mA ± (5% + 1 mA).	

4.5.2 Generator Fluoro Tests

This section applies only to R&F units.

Step	Action	Result	Check
1.	Place the generator into the fluoro mode of operation. Connect 'scope probe channel 1 input to TP6 and TP8 (kVp). Connect 'scope probe channel 2 input to TP11 and TP14 (fluoro mA). Use the kV signal to trigger the 'scope.	N/A	
2.	Place imaging system into non-ABS mode or cover I.I. input with lead.	N/A	
3.	Set 3 mA fluoro. Select the kV values shown below using the remote fluoro control if fitted, or the fluoro section of the console. A: 50 KV B: 65 KV C: 80 KV D: 100 KV E: 110 KV Measure the kVp at TP6 and TP8. Using scaling factors in figure 4-3 verify kV values per the RESULTS column:	 A: 50 kVp ± (10% + 1 kVp). B: 65 kVp ± (5% + 1 kVp). C: 80 kVp ± (5% + 1 kVp). D: 100 kVp ± (5% + 1 kVp). E: 110 kVp ± (5% + 1 kVp).	

4.5.2 Generator Fluoro Tests (Cont)

Step	Action	Result	Check
4.	Select 70 kVp fluoro. Select the fluoro mA values shown below: A: 1.0 mA B: 2.0 mA C: 4.0 mA D: 6.0 mA Measure the fluoro mA at TP11 and TP14. Using scaling factors in figure 4-3 verify mA values per the RESULTS column:	 A: 1.0 mA ± 20%. B: 2.0 mA ± 20%. C: 4.0 mA ± 15%. D: 6.0 mA ± 15%.	
5.	Press the PPS **+** and **-** buttons (if pulse fluoro option is fitted).	Verify that the pulsed fluoro rate increase and decreases.	
6.	Run a sufficiently long fluoro exposure to accumulate some time on the console fluoro display, and on the remote fluoro control if used Press the **ZERO** button on the console and on the remote fluoro control if applicable.	 Verify that the accumulated time is reset to ZERO after pressing each of the **ZERO** buttons.	

4.6.0 ACCEPTANCE TESTS (OPTIONAL INTERFACES)

Refer to separate supplements in this manual for further information IF APPLICABLE.

4.7.0 ACCEPTANCE TESTS (AEC)

This section applies only to generators with AEC.

- Review Section 3D: AEC Calibration
- Recheck the mAs, Dose, and O.D. as recorded during initial installation. Follow the appropriate steps in section 3D to verify the AEC calibration.

4.8.0 ACCEPTANCE TESTS (ABS)

This section applies only to non-digital R&F generators with ABS.

- Review section 3E: ABS calibration.
- Recheck the dose limits and input dose as described in the procedure.

4.9.0 ACCEPTANCE TESTS (HVL, LINEARITY AND REPRODUCIBILITY)

The procedure for performing reproducibility, linearity and HVL testing is contained in a separate document, part number 740917 which immediately follows this page.

SUPPLEMENT

REPRODUCIBILTY, LINEARITY, & HVL TESTING

CONTENTS:

1.0 INTRODUCTION

This supplement describes reproducibility, linearity, and half - value layer (HVL) tests which may be used to verify performance of medical X-ray generators.

NOTE:	***THIS SUPPLEMENT DETAILS TYPICAL REPRODUCIBILITY, LINEARITY, AND HVL TESTS. LOCAL REGULATIONS SHOULD ALWAYS BE CONSULTED PRIOR TO PERFORMING THESE TESTS, AS DETAILS MAY VARY IN SOME JURISDICTIONS, OR ADDITIONAL TESTS MAY NEED TO BE PERFORMED.***

WARNING:	***SOME EXPOSURES IN THIS SECTION MUST BE TAKEN AT THE MAXIMUM GENERATOR KVP. THE X-RAY TUBE MUST BE KNOWN TO BE CAPABLE OF OPERATION AT THAT KVP VALUE, AND THE TUBE SHOULD FIRST BE SEASONED TO ENSURE THAT OPERATION AT HIGH KVP VALUES WILL NOT BE PROBLEMATIC.***

2.0 EQUIPMENT SETUP

1. Place the radiation probe above the table approximately 25 cm (10”). Select an SID of approximately 100 cm (40”).

2. Place a lead diaphragm over the detector and adjust its height so that the X-ray beam covers the detector but does not over radiate the sides of the ‘R’ probe. Refer to figure 1.

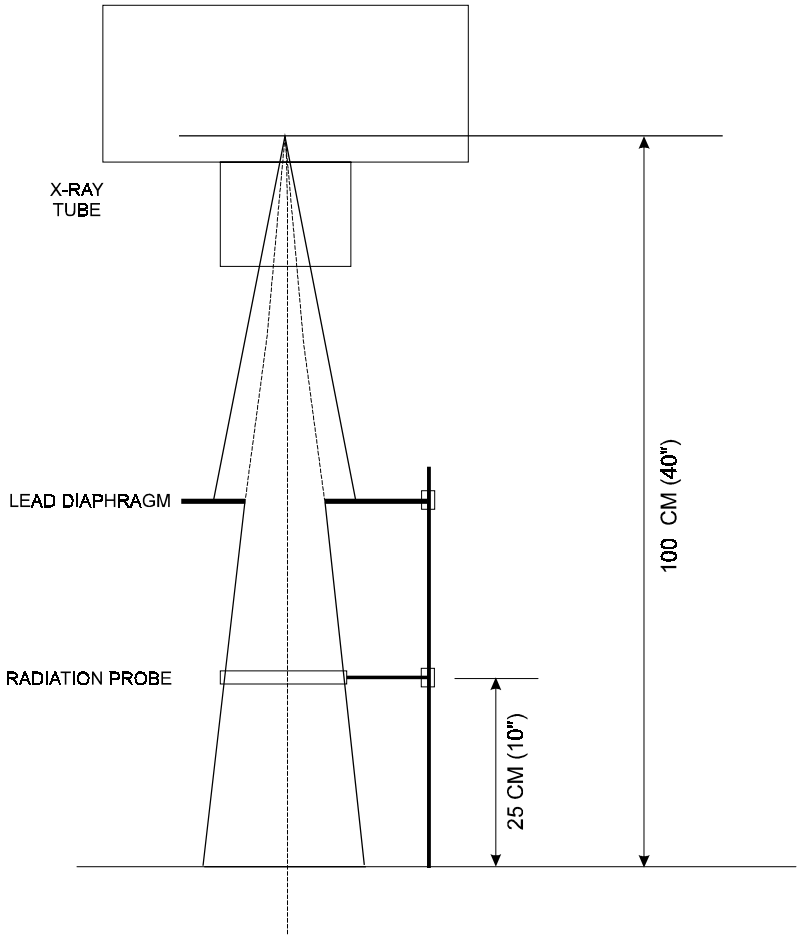


Figure 1: mR measurement setup

3.0 REPRODUCIBILITY

Calculate reproducibility as follows:

1. Using kV and mA/ms or mAs values per tables 1 to 4, make a series of 5 exposures.

2. Record each of the measured mR values in the appropriate table. Refer to step 3 before beginning step 2.

3. Record the preselected mAs for each series of exposures in the header of each table. For 3 point generators, this is the calculated mAs value where mAs = mA X time in seconds (example for 160 mA and 125 ms, mAs = 160 X 0.125 = 20 mAs).

3.0 REPRODUCIBILITY (Cont)

4. Calculate and record the average dose $\overline{mR}$.

5. Calculate the difference mR - $\overline{mR}$ for each exposure.

6. Square each difference from the previous step.

7. Calculate the sum of the differences squared.

8. Calculate the standard deviation (S) by using the formula.

$$S = \sqrt{\frac{\text{SUM OF DIFFERENCES}^2}{\text{N-1 SAMPLES}}}$$

9. Calculate reproducibility by dividing S by $\overline{mR}$.

10. Table 5 shows example reproducibility calculations.

11. If linearity is to be measured, it is suggested that dose measurements be taken at this time for entry into tables 6 and 7. Refer to 4.0 LINEARITY for details.

IN TABLES 1 TO 4, 3 POINT MEANS THAT FOR GENERATORS WHERE KV, MA, AND TIME SELECTION IS AVAILABLE, THE KV, MA AND MS VALUES SHOWN SHOULD BE USED. FOR GENERATORS WHERE 2 POINT OPERATION ONLY IS AVAILABLE, THE KV AND MAS VALUES SHOWN SHOULD BE USED.

3 point = Minimum kV, maximum mA, 100 ms.
2 point = Minimum kV, maximum mAs. mAs = _____

EXP No.	DOSE (mR)	DIFFERENCE	DIFFERENCE^2
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____

Calculate standard deviation (S) using formula at beginning of this section: S = _____

Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)

Table 1: Reproducibility

3.0 REPRODUCIBILITY (Cont)

3 point = Maximum kV, minimum mA, 100 ms. 2 point = Maximum kV, minimum mAs. mAs = _____			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____
Calculate standard deviation (S) using formula at beginning of this section: S = _____ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)			

Table 2: Reproducibility

3 point = 50% of maximum kV, 250 ms, mA to give 100 - 500 μR (1 - 5 μGy) dose. 2 point = 50% of maximum kV, mAs to give 100 - 500 μR (1 - 5 μGy) dose. mAs = _____			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____
Calculate standard deviation (S) using formula at beginning of this section: S = _____ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)			

Table 3: Reproducibility

3.0 REPRODUCIBILITY (Cont)

3 point = 80% of maximum kV, 250 ms, mA to give 100 - 500 μR (1 - 5 μGy) dose. 2 point = 80% of maximum kV, mAs to give 100 - 500 μR (1 - 5 μGy) dose. MAS = _____			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = _____	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = _____
Calculate standard deviation (S) using formula at beginning of this section: S = _____ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = _____ (not to exceed 0.045)			

Table 4: Reproducibility

EXAMPLE mAs = 20			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1	249.0	4.4	19.36
2	245.0	0.4	0.16
3	244.0	0.6	0.36
4	242.0	2.6	6.76
5	243.0	1.6	2.56
	$\overline{mR}$ = 244.6	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = 29.2
Calculate standard deviation (s) using formula at beginning of this section: S = 2.70 Calculate reproducibility = $\frac{S}{\overline{mR}}$ = 0.011 (not to exceed 0.045)			

Table 5: Reproducibility

4.0 LINEARITY

1. Record two additional series of dose measurements for entry into tables 6 and 7:
   - For table 6, use settings per table 3 ***EXCEPT*** use an mA (or mAs) value adjacent to the mA (or mAs) setting used in table 3.
   - For table 7, use settings per table 4 ***EXCEPT*** use an mA (or mAs) value adjacent to the mA (or mAs) setting used in table 4.
   - Record the mAs in the header of tables 6 and 7 as per 3.0 step 3.

1. Calculate and record the average dose $\overline{mR}$ for table 6 and 7.

2. Record the preselected mAs and the average dose values taken from tables 3 and 4, and from tables 6 and 7, at the top of the next page.

3. Using the appropriate mAs and $\overline{mR}$ values, calculate X_3, X_4, X_6, and X_7 in tables 8 and 9.

4. Calculate the coefficient of linearity, L, as per tables 8 and 9.

mAs = _____	
EXP No.	**DOSE (mR)**
1	
2	
3	
4	
5	
	$\overline{mR}$ = _____

Table 6: Linearity

mAs = _____	
EXP No.	**DOSE (mR)**
1	
2	
3	
4	
5	
	$\overline{mR}$ = _____

Table 7: Linearity

4.0 LINEARITY (Cont)

Record the mAs and $\overline{mR}$ values taken from tables 3, 4, 6, and 7 below.

Table 3	mAs_3 = _____	$\overline{mR}_3$ = _____
Table 4	mAs_4 = _____	$\overline{mR}_4$ = _____
Table 6	mAs_6 = _____	$\overline{mR}_6$ = _____
Table 7	mAs_7 = _____	$\overline{mR}_7$ = _____

$$X_3 = \frac{\overline{mR}_3}{mAs_3} = \_\_\_\_\_$$

$$X_6 = \frac{\overline{mR}_6}{mAs_6} = \_\_\_\_\_$$

$$L = \frac{X_3 - X_6}{X_3 + X_6} = \_\_\_\_\_ \text{ (not to exceed 0.095)}$$

In the numerator of the above equation, use the absolute value of $X_3 - X_6$ (disregard the minus sign).

Table 8: Linearity

$$X_4 = \frac{\overline{mR}_4}{mAs_4} = \_\_\_\_\_$$

$$X_7 = \frac{\overline{mR}_7}{mAs_7} = \_\_\_\_\_$$

$$L = \frac{X_4 - X_7}{X_4 + X_7} = \_\_\_\_\_ \text{ (not to exceed 0.095)}$$

In the numerator of the above equation, use the absolute value of $X_4 - X_7$ (disregard the minus sign).

Table 9: Linearity

5.0 H.V.L. EVALUATION

1. Be sure the X-ray source assembly (X-ray tube and beam limiting device) is fully assembled and functional.

2. Use the test setup as per figure 1.

3. Set the generator as follows: 3 point generators, 80 kV, 200 mA, 50 ms, large focus. For 2 point generators use 80 kV, 200 mA if this can be set, and 10 mAs.

4. Take a series of three exposures and record the mR values in table 10. Calculate and record the average of the three exposures.

5. Place 2 mm of Al on top of the lead diaphragm (total of 2 mm added), repeat the exposure and record the mR value in table 10.

6. Place an additional 1 mm of Al on top of the lead diaphragm (total of 3 mm added), repeat the exposure; and record the mR value in table 10.

7. Place an additional 3 mm of Al on top of the lead diaphragm (total of 6 mm added), repeat the exposure; and record the mR value in table 10.

8. The relative transmission for the average of the three mR values where no Al was added is assigned a value of 1.00. Using that base, assign relative transmission values to the remaining mR values. For example, if the average mR value was 247 and has a relative transmission factor of 1.00, then 162 mR will have a relative transmission of 162 / 247 = 0.66.

9. Plot the relative transmission values in figure 1. This should produce a straight line on the graph since the X-axis is logarithmic.

10. Interpolate to determine the HVL. The Al thickness at a relative transmission of 0.5 will be the required HVL value.

11. Repeat steps 4 to 10: 3 point generators, 100 kV, 200 mA, 50 ms, large focus. For 2 point generators use 100 kV, 200 mA if this can be set, and 10 mAs. Use table 11 to record the values and figure 2 to plot the results

12. Table 12 and figure 3 show example HVL determination.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0		
0		
0		
0 (Average of three readings)		1.00
2		
1		
3		

Table 10: HVL dose values 80 kVp

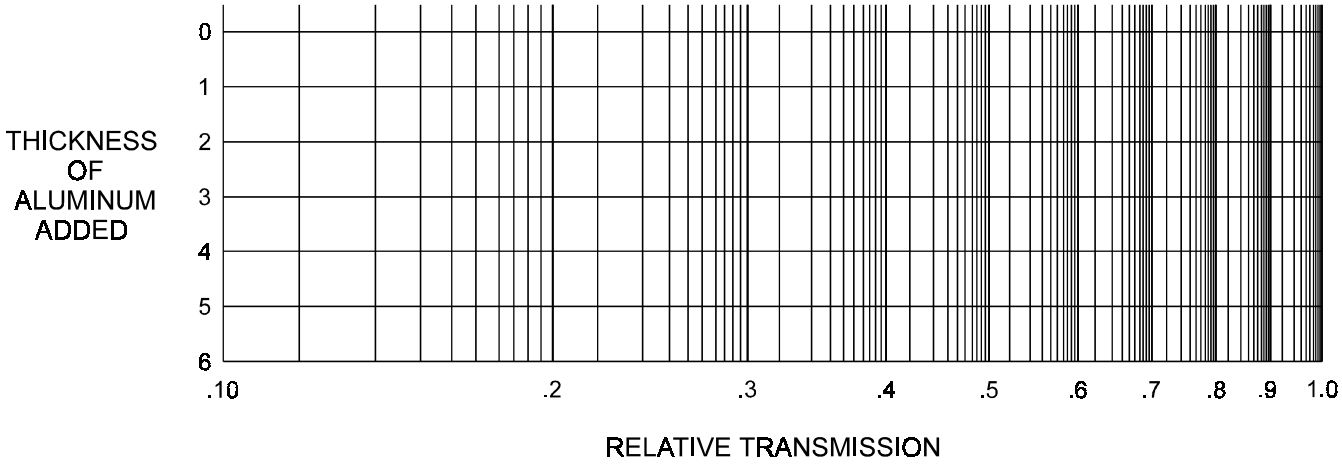


Figure 1: HVL plot 80 kVp

For 80 kVp, the HVL must be ≥ 2.3 mm Al.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0		
0		
0		
0 (Average of three readings)		1.00
2		
1		
3		

Table 11: HVL dose values 100 kVp

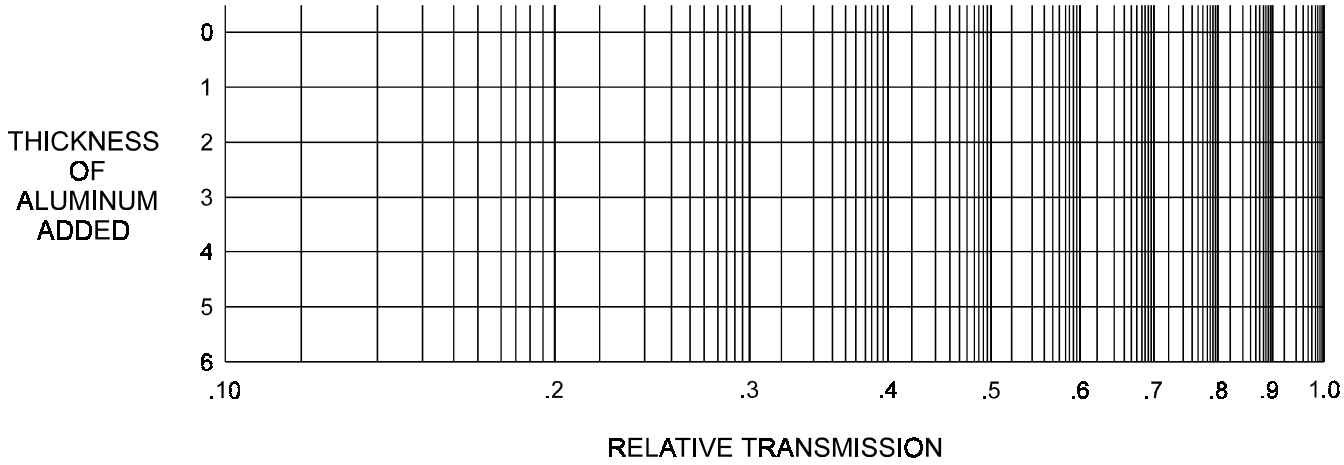


Figure 2: HVL plot 100 kVp

For 100 kVp, the HVL must be ≥ 2.7 mm Al.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0	249	
0	244	
0	247	
0 (Average of above three readings)	247	1.00
2	162	.66
1	131	.53
3	70	.28

Table 12: HVL dose values (example)

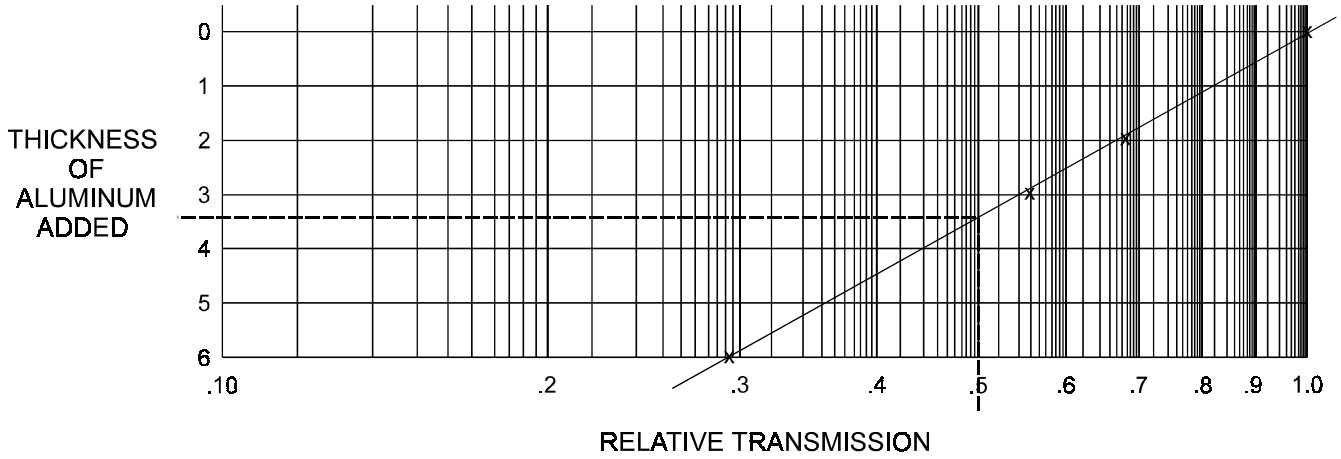


Figure 3: HVL plot (example)

By interpolating the thickness of Al at a relative transmission value of 0.5, it can be seen that the HVL is approximately 3.3.

CHAPTER 5

TROUBLESHOOTING

CONTENTS:

5.1.0 INTRODUCTION

The Millenia and Indico 100 console will display status messages on the LCD display during normal and abnormal operation of the generator. This chapter contains tables of those messages and suggests actions to be taken by service personnel to correct any malfunctions that may occur.

5.2.0 STATUS AND ERROR CODES

5.2.1 Operator Messages

These messages indicate the status of the generator. No action is required.

MESSAGE	DESCRIPTION
INITIALIZATION	Displayed during power up sequence.
SPINNING ROTOR	Displayed when prep state is active.
X-RAY READY	Displayed when generator is ready to expose
X-RAY ON	Displayed during both a rad and fluoro exposure.

5.2.2 Limit Messages

These messages indicate that an exposure has been requested that exceeds one or more limits.

MESSAGE	PROBLEM	ACTION
TUBE KV LIMIT	Requested kV not allowed as tube kV limit has been reached.	None.
GEN KV LIMIT	Requested kV not allowed as generator kV limit has been reached.	None.
TUBE MA LIMIT	Requested mA not allowed as tube mA limit has been reached.	None.
GEN MA LIMIT	Requested mA not allowed as generator mA limit has been reached.	None.
TUBE KW LIMIT	Requested parameter not allowed as tube kW limit has been reached.	None.
GEN KW LIMIT	Requested parameter not allowed as generator kW limit has been reached.	None.
TUBE MAS LIMIT	Requested mAs not allowed as tube mAs limit has been reached.	None.
GEN MAS LIMIT	Requested mAs not allowed as generator mAs limit has been reached.	None.
GEN MS LIMIT	Requested ms not allowed as generator ms limit has been reached.	None.
CAL LIMIT	Requested parameter not calibrated.	Recalibrate X-ray tube or select a calibrated parameter.
AEC DENSITY LIM	Requested density not programmed.	Select another density or program requested density step.
ANODE HEAT WARN	Anode has exceeded programmed warning level.	Wait for anode to cool.
FL TIMER WARN	Fluoro interval timer ≥ 5.0 mins.	Reset fluoro timer.
INVALID PARAM	Generator detected invalid parameter within received message, message ignored.	Select valid parameter.
HOUSE HEAT WARN	X-ray tube housing heat has exceeded housing warning limit.	Wait for housing to cool.

5.2.2 Limit Messages (Cont)

GEN DUTY WARNING	The generator has exceeded its duty cycle warning limit.	Re-evaluate technique factors. Allow generator to cool if possible. If exposures are continued, serious generator damage may result due to overheating.

5.2.3 Error Messages

These messages indicate that an error has occurred. The errors are logged in the error log, previous errors should be reviewed by service personnel before taking further action.

ERROR CODE	MESSAGE	PROBLEM	ACTION
E001	GEN EPROM ERR	Generator CPU EPROM has been corrupted.	Call product support for new generator CPU EPROM.
E003	GEN NVRAM ERR	Generator CPU NVRAM data has been corrupted.	Re-initialize generator CPU NVRAM using generator factory defaults.
E004	GEN RTC ERROR	Generator CPU real time clock is not functioning.	Reset time and date.
E005	PS CONTACT ERR	Main contactor in HF power supply did not energize.	Call product support.
E006	ROTOR FAULT	1. Rotor starter may have detected a current fault in the stator. 2. Power supply was not ready to start rotor.	Power unit off and retry rotor start.
E007	FILAMENT FAULT	Power supply has detected filament current <2 amps.	1. Check for open filament in X-ray tube. 2. Check for poor connections in the cathode cable. 3. Check fuses on filament board(s).

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E008	KV/MA FAULT	Power supply has detected a fault in the kV or mA output during an exposure and immediately terminated the exposure. This may be caused by arcing in the X-ray tube, arcing of the HV cables, or HT tank.	1. If arcing of the X-ray tube is suspected, check condition of tube. The X-ray tube may be damaged or simply require "seasoning". Refer to chapter 6 for tube seasoning procedure. 2. If failure of HT tank is suspected, contact product support.
E009	PS NOT READY	Power supply is not ready to make an exposure.	Retry exposure.
E011	HIGH MA FAULT	Generator CPU detected mA greater than allowed tolerance.	Recalibrate X-ray tube.
E012	LOW MA FAULT	Generator CPU detected mA less than allowed tolerance.	Recalibrate X-ray tube.
E013	MANUAL TERMIN	Operator released exposure switch during exposure.	1. Re-take exposure if necessary. 2. Check for faulty switch contacts or wiring.
E014	AEC BUT ERROR	AEC exposure exceeded allowed back up time.	1. Check exposure technique settings. 2. Check that correct AEC chamber is energized.
E015	AEC BU MAS ERR	AEC exposure exceeded allowed back up mAs.	1. Check exposure technique settings. 2. Check that correct AEC chamber is energized.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E016	TOMO BUT ERROR	Tomo exposure exceeded back up time.	1. Check exposure technique settings. 2. Increase tomo back up time if necessary.
E017	NOT CALIBRATED	Selected mA not calibrated for selected kV.	Recalibrate X-ray tube.
E018	PREP TIMEOUT	Generator has been in prep state too long.	Reduce length of time in prep state.
E019	ANODE HEAT LIMIT	Selected parameters will cause X-ray tube to exceed its programmed anode heat limit.	Reduce parameters or wait for tube to cool.
E020	THERMAL INT #1	X-ray tube # 1 too hot and its thermal switch has opened.	Wait for X-ray tube # 1 to cool.
E021	THERMAL INT #2	X-ray tube # 2 too hot and its thermal switch has opened.	Wait for X-ray tube # 2 to cool.
E022	DOOR INTERLOCK	Door is open.	Close door.
E023	COLLIMATOR ERR	Collimator is not ready.	Check collimator.
E024	CASSETTE ERROR	Cassette is not ready.	Check cassette.
E025	II SAFETY INT	II safety is not ready.	Check II safety.
E026	SPARE INT	Spare input is not ready.	Check spare input.
E028	PREP SW CLOSED	Prep input active during power on initialization phase.	Check prep switch and input for short circuit.
E029	X-RAY SW CLOSED	X-ray input active during power on initialization phase.	Check X-ray switch and input for short circuit.
E030	FLUORO SW CLOSED	Fluoro input active during power on initialization phase.	Check fluoro switch and input for short circuit.
E031	REMOTE COMM ERR	Communication error detected with remote fluoro control unit.	1. Check remote fluoro control cable for damage and proper connection. 2. Turn power off and then on to Reset Generator.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E032	CONSOLE COMM ERR	Generator has detected error in communication to console.	1. Check console cable for damage and proper connection. 2. Turn power off and then on to reset generator.
E033	GEN BATTERY LOW	Generator detects lithium battery voltage is low.	Replace lithium battery.
E034	+12VDC ERROR	+12VDC rail is out of tolerance.	Check +12VDC rail.
E035	-12VDC ERROR	-12VDC rail is out of tolerance.	Check -12VDC rail.
E036	+15VDC ERROR	+15VDC rail is out of tolerance.	Check +15VDC rail.
E037	-15VDC ERROR	-15VDC rail is out of tolerance.	Check -15VDC rail.
E038	CAL DATA ERROR	Generator detects corrupt calibration data.	Re-calibrate X-ray tube(s).
E039	AEC DATA ERROR	Generator detects corrupt AEC data.	Reprogram AEC data or set factory defaults.
E040	FLUORO DATA ERROR	Generator detects corrupt Fluoro data.	Reprogram fluoro data or set factory defaults.
E041	REC DATA ERROR	Generator detects corrupt receptor data.	Reprogram receptor data or set factory defaults.
E042	TUBE DATA ERR	Generator detects corrupt tube data.	Reprogram tube data or set factory defaults.
E043	KV ERROR	KV detected in non x-ray state.	Switch OFF generator. Prevent further use of generator. Call product support.
E044	COMM ERROR	Received communication message not valid and ignored.	Reset error.
E045	NOT SUPPORTED	Received message valid, but not supported by this system.	Reset error.
E046	MODE INHIBITED	Received message valid, but not allowed during present state.	Reset error.
E047	FL TIMER LIMIT	Fluoro Timer has exceeded time limit.	Reset Fluoro timer.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E048	FOCUS MISMATCH	Focus selected does not match current focus enabled by power supply.	Check power supply interface cables between power supply and generator CPU board.
E049	NOT ENABLED	Requested function not programmed to be enabled.	Reprogram to enable function.
E050	GEN DATA ERROR	Generator detects corrupt generator limit data.	Reprogram generator limit data or set factory defaults.
E051	AEC DEVICE ERR	Generator has detected no feedback signal from AEC device.	1. Check that X-ray tube is pointing at correct AEC device. 2. Check AEC cable for damage and proper connection.
E052	HIGH SF CURRENT	Generator detects small focus filament current greater than limits in standby mode.	Check small focus filament board.
E053	HIGH LF CURRENT	Generator detects large focus filament current greater than limits in standby mode.	Check large focus filament board.
E054	AEC OUT OF RANGE	AEC reference has reached a maximum or minimum limit.	Re-adjust AEC calibration including density to operate within AEC range (O to 1OVDC).
E055	NO FIELDS ACTIVE	AEC enabled but no fields are selected.	Select AEC field(s).
E056	NO TUBE SELECTED	All Receptors have no X-ray tube programmed.	Program receptor(s) with tube number.
E057	AEC STOP ERROR	AEC stop signal (P.T. stop signal) is active low indicating exposure is finished during prep state.	1. Check that P.T. ramp does not exceed P.T. reference during prep state. 2. Check AEC device for proper operation.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E058	CONSOLE BUT ERR	Console has detected exposure exceeded backup time and terminated exposure.	Call product support.
E059	HOUSE HEAT LIMIT	X-ray tube housing has exceeded limit.	Wait for tube to cool.
E060	EXP KV HIGH	KV exceeds high KV tolerance level.	1. Check the output of the kV reference DAC on the generator CPU board. 2. Measure the output of the generator with a dynalyzer or a non-invasive kVp meter.
E061	EXP KV LOW	KV exceeds low KV tolerance level.	1. Check the output of the kV reference DAC on the generator CPU board. 2. Measure the output of the generator with a dynalyzer or a non-invasive kVp meter.
E062	EXP_ SW ERROR	The EXP_SW signal on the generator Interface and generator CPU board is enabled when it should be disabled.	Call product support.
E063	FACTORY DEFAULTS	SW1 switch 8 on the generator CPU board is set to default the generator CPU NVRAM with factory defaults.	Set SW1 switch 8 to its non default position. The generator will not exit the initialization phase until this switch is set.
E070	SOFTWARE KEY ERR	Defective or missing GAL U29 on generator CPU board 734573.	Call product support for new GAL U29.
E100	CAL_MAX MA ERR	Maximum mA has been exceed during auto calibration.	Repeat auto calibration and/or decrease standby current.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E101	CAL_DATA LIMIT	Auto calibration has exceeded data table length due to an excessive number of exposures.	1. Check to see if the filament standby current is too low. 2. Retry auto calibration.
E102	CAL_MAX FIL ERR	Maximum filament current for the selected focus has been exceeded.	1. Check to see if the maximum filament current limit can be increased. 2. Retry auto calibration.
E103	CAL_MAN TERM	Operator released exposure button during auto calibration.	Retry auto Calibration.
E104	CAL_NO MA	No mA feedback detected during auto calibration.	Check power supply Interface cables between HF power supply and generator CPU board.
E105	CAL_MIN MA ERR	Minimum generator mA was exceeded at start of calibration. This is usually caused by too high a filament standby current on the primary and or secondary filament. (Primary is the current filament being calibrated, secondary is the other filament and applies only to generators with two independent filament supplies).	Reduce filament standby current on primary and/or secondary filament.

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CHAPTER 6

REGULAR MAINTENANCE

CONTENTS:

6.1.0 INTRODUCTION

This chapter of the manual provides a recommended schedule for periodic maintenance of the Millenia and Indico 100 family of generators.

6.2.0 X-RAY GENERATOR UPDATE/SERVICE RECORD

The X-ray generator update/service record is stored in the upper cabinet of the generator (Millenia) or on the back of the panel which accesses the control boards in the lower cabinet (Indico 100). The installation date and location should be recorded on this form at the time of the original site installation.

Service and repairs must be recorded in the update/service record. The record should be as thorough as possible, detailing the scope and type of work that was performed (all service and a record of all replacement parts that were installed). Additionally, the person performing the work should date and sign the record.

This information will be invaluable in the future for traceability and to ensure continued compatibility of the generator.

6.3.0 MAINTENANCE SCHEDULE

WARNING: ***MAINTENANCE IS TO BE PERFORMED ONLY BY COMPETENT, TRAINED PERSONNEL WHO ARE FAMILIAR WITH THE POTENTIAL HAZARDS ASSOCIATED WITH THIS EQUIPMENT.***

NOTE: ***MAINTENANCE SCHEDULE FREQUENCY MAY BE DETERMINED BY CERTAIN REGULATORY REQUIREMENTS OF THE COUNTRY OR STATE IN WHICH THE INSTALLATION IS LOCATED. ALWAYS CHECK THE LOCAL CODES AND REGULATIONS WHEN DETERMINING A MAINTENANCE SCHEDULE.***

WARNING: ***ALWAYS SWITCH OFF MAINS POWER TO THE GENERATOR AND WAIT A MINIMUM OF 5 MINUTES FOR CAPACITORS TO DISCHARGE BEFORE BEGINNING ANY PREVENTATIVE MAINTENANCE, INCLUDING CLEANING.***

WARNING: ***OBSERVE ESD PRECAUTIONS. KEEP ALL STATIC - SENSITIVE COMPONENTS AND CIRCUIT BOARDS IN THEIR STATIC - SHIELDING PACKAGING UNTIL READY TO INSTALL. ENSURE THAT YOU ARE GROUNDED AT ALL TIMES WHEN HANDLING STATIC - SENSITIVE COMPONENTS AND CIRCUIT BOARDS.***

6.3.0 MAINTENANCE SCHEDULE (Cont)

Maintenance Frequency	Description of Preventative Maintenance
Every 6 Months AND whenever a related certifiable X-ray component is replaced:	1. Clean and re-grease all HV connections using vapour proof compound. 2. Clean the control console, remote fluoro control (if used) and main cabinet as needed. **REFER TO 6.5.0 CLEANING BEFORE PROCEEDING** 3. Perform the X-ray tube auto calibration routine, refer to chapter 2. 4. Verify the calibration of the generator, refer to chapter 4 of this manual. 5. Test the X-ray tube thermal switch circuits in the generator. Disconnect the tube thermal switch(s) and verify the correct error message, and that X-ray exposures are inhibited. 6. For fan cooled Indico 100 generators in particular, remove accumulated dust from the cooling vents. Vacuuming is recommended. 7. Perform any additional tests required by laws governing this installation.
Every 12 months:	1. Examine the following for any visible damage and replace any damaged components: • The exterior of the control console and remote fluoro control if used, including the membrane switch assembly. • The cable between the control console and the generator main cabinet and between the remote fluoro control (if used) and generator main cabinet. • The handswitch and fluoro footswitch (if used) and the cables connecting these to the console. 2. Open the generator cabinet and examine the unit for any visible damage: missing or loose ground connections, oil leaks, damaged cables etc. 3. Ensure that there are no obstructions blocking any of the ventilation holes or louvers on the generator cabinet.
Every 5 years:	Replace the lithium battery on the CPU board in the control console and on the generator CPU board in the main cabinet. Refer to the spares list in chapter 8 for the required part number. Refer to subsection 6.7.0 for battery replacement procedure.

6.4.0 OIL FILL/LEVEL CHECK (HT TANK)

The insulating oil level in the HT transformer does NOT require periodic checking under normal conditions. However, if there is evidence of possible oil loss, the procedure for checking the correct oil level follows. Refer to 6.4.1 for Millenia generators, and to 6.4.2 for Indico 100 generators.

6.4.1 Millenia Oil Fill/Level Check

1. Using a suitable wrench, remove the oil fill cap on top of the HT transformer.

2. Measure the oil level from the TOP surface of the oil fill flange using a **clean** ruler. The oil level should be in the range of 7/8" (22 mm) to 1 3/8" (35 mm) from the top of the flange. Add oil if the oil level is low, that is greater than 1 3/8" (35 mm) from the top.

3. Use only fresh oil, type Shell DIALA AX or equivalent. Take care not to damage delicate components inside the tank if using a funnel for oil fill.

4. Replace the oil filler cap and tighten when finished. Wipe up any oil spills. Dispose of soiled absorber in compliance with government requirements and ensure conformity to local disposal regulations.

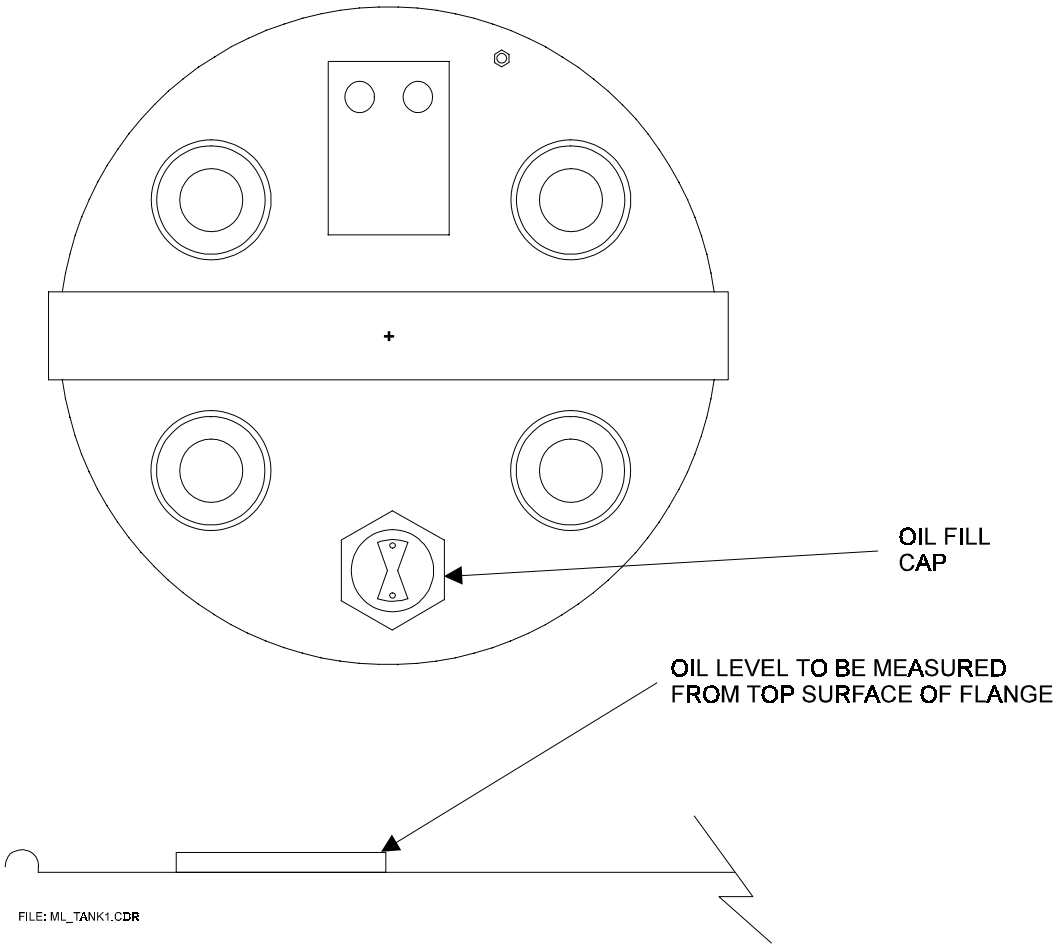

Figure 6-1: Millenia HT tank oil fill

6.4.2 Indico 100 Oil Fill/Level Check

1. Loosen the oil fill plug screw on the Indico 100 tank lid.

2. With the screw sufficiently loosened, remove the rubber (neoprene) plug.

3. Use a **clean** ruler, strip of cardboard, or other equivalent material to determine the oil level -- **measured always from the TOP surface of the HT tank's lid.**
   - Normally the oil level should be between 0.5 -0.9 inches (13 - 23 mm) from the top of the tank lid.
   - If the oil level is between 0.9 - 1.3 inches (23 - 33 mm) from the top of the tank lid, then clean oil should be added as needed.
   - If the oil level is greater than 1.3 inches (33 mm) below the top of the tank lid, please consult the factory.

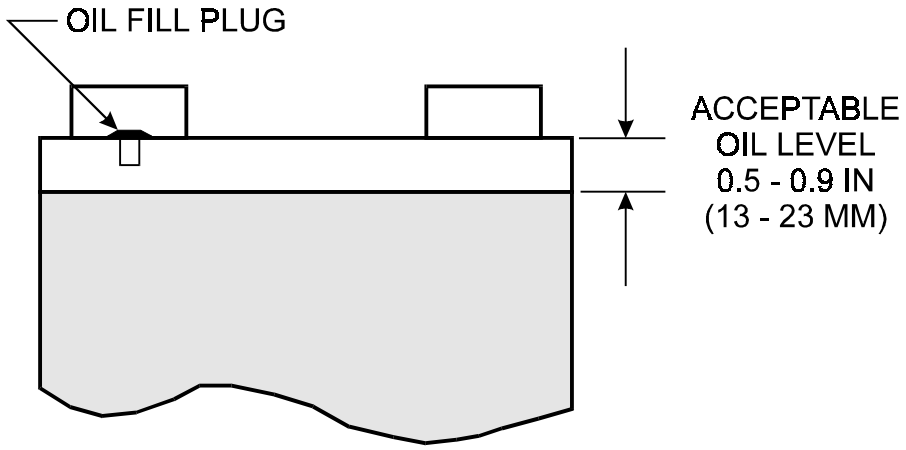

Figure 6-2: HT tank oil level

4. Use only fresh oil, type Shell DIALA AX or equivalent. If a funnel is used to add the oil, take care not to damage any of the delicate components inside the tank.

5. Replace the oil fill plug. Once the plug is installed and the screw properly seated, tighten the screw 4 turns. This will secure the oil fill plug. Wipe up any oil spills. Dispose of soiled absorber in compliance with government requirements and ensure conformity to local disposal regulations. THE OIL DOES NOT CONTAIN PCBs

6.5.0 CLEANING

- Never use anything other than soap and water to clean plastic surfaces. Other cleaners may damage the plastic.
- **Never use any corrosive, solvent or abrasive detergents or polishes.**
- Ensure that no water or other liquid can enter any equipment. This precaution prevents short circuits and corrosion forming on components.
- Methods of disinfection used must conform to legal regulations and guidelines regarding disinfection and explosion protection.
- If disinfectants are used which form explosive mixtures of gases, these gases must have dissipated before switching on the equipment again.
- Disinfection by spraying is not recommended because the disinfectant may enter the X-ray equipment.
- If room disinfection is done with an atomizer, it is recommended that the equipment be switched OFF, allowed to cool down and covered with a plastic sheet. When the disinfectant mist has subsided, the plastic sheet may be removed and the equipment be disinfected by wiping.

6.6.0 EPROM REPLACEMENT

WARNING: ***PLEASE TAKE APPROPRIATE ELECTROSTATIC PRECAUTIONS AT ALL TIMES WHEN HANDLING THE EPROM's.***

6.6.1 Console EPROM

1. With the generator mains power switched OFF, open the console to gain access to the console EPROM. Refer to chapter 2, the section *CHECKING THE RAM BACKUP BATTERY VOLTAGE*, for the procedure to access the console CPU board (23 X 56 cm consoles) or the console board (31 X 42 cm consoles).

2. Locate and carefully remove the existing EPROM on the console board / console CPU board (refer to figure 1E-4).

3. Carefully insert the replacement EPROM into the socket *observing the orientation per figure 1E-4*.

4. Re-assemble the console as per the procedure in chapter 2.

5. Refer to 6.6.4 before re-energizing the generator.

6.6.2 Power EPROM

1. With the generator mains power switched OFF, locate and carefully remove the existing power EPROM on the generator CPU board (U38 or U41, refer to figure 1E-1).

2. Carefully insert the replacement EPROM into the socket *observing the orientation per figure 1E-1*. **NOTE THAT THE REPLACEMENT EPROM MAY HAVE FOUR LESS PINS THAN THE SOCKET IT IS TO BE INSERTED INTO. IF THIS IS SO, THE EMPTY PINS MUST BE ON THE PIN 1 SIDE OF THE EPROM AS SHOWN IN FIGURE 1E-1.**

3. Refer to 6.6.4 before re-energizing the generator.

6.6.3 Dual Speed Starter EPROM (If fitted)

1. Switch the generator mains power OFF, **AND WAIT 5 MINUTES FOR THE DC BUS CAPACITORS TO FULLY DISCHARGE.**

STEPS 2 AND 3 APPLY TO MILLENIA GENERATORS ONLY. IN INDICO 100 GENERATORS, THE DUAL SPEED STARTER BOARD IS FULLY ACCESSIBLE WITH THE APPROPRIATE GENERATOR SIDE PANEL(S) REMOVED.

2. Loosen the two nuts securing the clamping bracket at the top of the dual speed starter. Slide the bracket up and gently remove the dual speed starter assembly. The cables connected to the dual speed starter do not need to be removed in order to change the EPROM.

3. Carefully rotate the dual speed starter chassis to fully expose the dual speed starter board inside the unit.

4. Locate and carefully remove the existing EPROM on the dual speed starter board (U26, refer to figure 1E-6).

5. Carefully insert the replacement EPROM into the socket *observing the orientation per figure 1E-6*.

6. Reinstall the dual speed starter assembly by reversing steps 2 and 3 (Millenia).

6.6.4 Resetting Factory Defaults

Should the ***part number*** *(not revision)* of the replacement EPROM be different from the EPROM being replaced, then the FACTORY DEFAULT procedure(s) must be performed as detailed below. This will initialize the CPU's NVRAM as required by the new software and sets the data to it's factory configured state. Note that there are separate procedures for the console CPU board and for the generator CPU board.

CONSOLE CPU FACTORY DEFAULTS:

1. With the power OFF, set switch 8 of SW1 on the console CPU board to its **ON** position.

2. Power ON the generator. The console will prompt for a **YES** or **NO** to loading defaults for two conditions (console settings and APR memory). Select **YES** to both.

3. Power OFF the console. Reset switch 8 of SW1 on the console CPU board to its **OFF** position.

This will initialize both the CONSOLE settings (refer to CONSOLE settings in chapter 3C) and the APR to the factory default settings.

GENERATOR CPU FACTORY DEFAULTS:

1. With the power OFF, set switch 8 of SW1 on the generator CPU board to its **OFF** position.

2. Power ON the generator. After the initialization is complete, the console will display the message **FACTORY DEFAULTS.**

3. Power OFF the generator. Reset switch 8 of SW1 on the generator CPU board to its **ON** position.

This will initialize all generator data to the factory defaults (tube selection, generator limits, receptor setup, I/O configuration, AEC setup, AEC calibration, fluoro setup, tube calibration, time & date, error log and statistics).

6.7.0 BATTERY REPLACEMENT

To replace the battery on the console CPU board or on the generator CPU board, follow the procedure below. Refer to the figure showing the location of these batteries in chapter 2, in the section “CHECKING THE RAM BACKUP BATTERY VOLTAGE”. Refer to that section in chapter 2 for console disassembly instructions to gain access to the console CPU board if required.

NOTE: ***THE CONSOLE BATTERY SHOULD BE REPLACED WITH THE GENERATOR POWERED UP. THIS WILL PREVENT THE CONSOLE DATA FROM BEING LOST WHEN THE BATTERIES ARE REMOVED.***

THIS IS THE ONLY EXCEPTION TO THE RULE OF NOT SERVICING THE GENERATOR WHILE THE POWER IS ON. FAMILIARIZE YOURSELF WITH THE HIGH VOLTAGE LOCATIONS AND HAZARDS BEFORE REPLACING THIS BATTERY.

1. Remove the battery from the holder by gently prying under the battery at the access slot in the battery holder using a small screwdriver. Slide the battery over the edge of the holder and remove it when it is free.

2. Check the voltage of the new battery prior to inserting it. This should be nominally 3.0V, do not use if it is under 2.80 V.

3. Wipe the replacement battery with a clean cloth, and ensure that the holder is clean and free of debris before inserting the battery.

4. Gently lift the spring contact on the holder and insert the replacement battery positive (+) side up

6.8.0 TUBE CONDITIONING / SEASONING

Tube conditioning or "seasoning" is particularly important for new tubes or tubes that have not been used for several days. This should be performed on each X-ray tube before attempting auto calibration, as an unseasoned tube may not operate properly at higher kV values without arcing. Refer to the X-ray tube manufacturer's instructions, if available, for the tube conditioning or "seasoning" procedure. If the X-ray tube manufacturers instructions are not available, the following procedure may be used:

6.8.1 Tube Conditioning (Overview)

The generator does X-ray tube auto calibration at 50 kV, 60 kV, 70 kV, 80 kV, 100 kV and 120 kV. The tube normally needs to be seasoned before it can be operated at the higher voltages encountered during auto calibration.

Tube seasoning is started by auto calibrating the kV stations up to and including part of the 70 kV station. The tube is then seasoned at 70 kV. Progressively higher kV stations are then auto calibrated and seasoned. Finally the entire kV and mA range is auto calibrated, then the tube is seasoned at the remaining high kV values.

Manually releasing the exposure button during auto calibration of a particular kV station in the following procedure prevents the generator from attempting operation beyond that kV/mA value.

NOTE: ***THE TUBE MANUFACTURER'S RECOMMENDED SEASONING PROCEDURE, IF AVAILABLE, MUST ALWAYS BE USED IN PLACE OF THE FOLLOWING PROCEDURE.***

NOTE: ***LOW SPEED ONLY EXPOSURES ARE RECOMMENDED FOR THE SEASONING EXPOSURES, TO PREVENT EXCESSIVE HEAT BUILD-UP IN THE HOUSING FROM THE STATOR WINDINGS OR THE ROTOR BEARINGS.***

X-ray tubes that have not been used for more than 8 hours may suffer thermal shock if operated at high mA and kV without a warm-up procedure. A cold anode (Molybdenum) is very brittle and when suddenly heated over a small area may experience thermal cracking of the anode surface, eventually leading to permanent tube damage.

6.8.2 Tube Conditioning (Procedure)

The procedure below is intended for seasoning an X-ray tube prior to attempting tube auto calibration. To season a tube that does not need to be calibrated, simply follow steps 2, 4, 6, 8, and 9.

1. Start the tube auto calibration sequence, and manually terminate the exposure at 70 kV and 250 mA.

2. Season the tube at 70 kV by taking approximately 10 exposures of 200 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

3. Restart the auto calibration sequence and manually terminate the exposure at 100 kV and 250 mA.

4. Season the tube at 100 kV by taking approximately 5 exposures of 200 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

5. Restart the auto calibration sequence and manually terminate the exposure at 120 kV and 160 mA.

6.8.2 Tube Conditioning (Procedure) Cont

6. Season the tube at 120 kV by taking approximately 5 exposures of 160 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

7. Restart the auto calibration sequence and allow the auto calibration sequence to complete.

8. Season the tube at 130 kV by taking approximately 5 exposures of 100 mA and 50 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

9. Repeat step 8 at 140 kV, and then at 145 kV.

6.9.0 END OF PRODUCT LIFE

If the generator has completed its useful service life, local environmental regulations must be complied with in regard to disposal of possible hazardous materials used in the construction of the generator.

In order to assist with this determination, the noteworthy materials used in the construction of this generator are itemized below:

ITEM

- Electrical insulating oil in HT tank. This is a mineral oil with trace additives (60 Litre (17 U.S. gal) for Millenia, 25 Litre (6.5 U.S. gal) for Indico 100).
- Solder (lead/tin).
- Epoxy fiberglass circuit board materials, tracks are solder on copper.
- Wire, tinned copper. Insulated with PVC, tefzel, or silicone.
- Steel and / or aluminum (generator cabinet and console chassis).
- Plastic (console enclosure and console membrane).
- Electrical and electronic components: IC's, transistors, diodes, resistors, capacitors, etc.

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CHAPTER 7

THEORY OF OPERATION

CONTENTS:

7.0 INTRODUCTION

The Indico 100 series X-ray generator consists of a high voltage power supply (including the HT oil tank and low or dual speed starter), generator control electronics, and a control console.

Included in the power supply are:

- Power input circuits.
- One to three inverter modules.
- A resonant power circuit.
- A high voltage oil tank capable of driving one or two X-ray tubes.
- A rotor supply -- a standard low speed starter (LSS) or an optional dual speed starter (DSS).
- Power supply control circuits.
- One or two filament supplies.
- Auxiliary power circuits.

The HT oil tank consists of:

- High voltage transformers.
- Filament transformers.
- High voltage multiplier boards
- Tube selection relay (two tube tanks only).

The generator control electronics consist of:

- Generator interface board.
- Room interface board.
- Generator CPU board.
- Optional automatic exposure control (AEC) and digital interface assemblies.

Included in the control console are:

- An LCD fluorescent backlight display.
- An LED display/switch assembly.
- Console control and interface circuits.

7.1 FUNCTIONAL OVERVIEW

The following is a functional overview of the three main subassemblies that comprise the complete generator.

7.1.1 Control Console

- The console uses LED and LCD displays, to allow the operator to view the exposure parameters selected. The radiographic display has a section for kV, mA, exposure time and a density display for AEC applications.

- The LED and LCD displays on the console also provide information to the operator regarding conditions of the generator and programming functions, along with any error messages. The console also has several pushbuttons to select the different operating modes and features of the generator. Among the available operating modes and features are: AEC; ABS (automatic brightness stabilization); mA/ms (current/time); mAs (current-time product); film screen - fast, medium and detail; focus/filament - large or small; six bucky/image receptors; AEC field - left, centre, right; X-ray preparation; X-ray exposure and generator ON/OFF buttons.

- Inside the console there is a microprocessor that executes the main operating system program. This includes an EPROM which contains the main program code, and a RAM chip which contains tables for use with the main program, such as generator status and error messages. Tube limit data and automatic programmed radiography (APR) exposure parameters are also stored in RAM. A battery located inside the console supplies power to the RAM chip to ensure that the data is non-volatile, and to keep the real time clock operational when the power is switched off.

- The LCD display receives its power from a high voltage DC to AC converter, and the console switches interface with the microprocessor through ribbon cables.

- The communication between the console and the generator is achieved via a 15 pin shielded cable. This cable provides a bi-directional serial link from the console to the generator control circuits. Operational commands and status signals are sent, via this link, from the console microprocessor to the generator CPU board.

7.1.2 High Voltage Power Supply

The power supply section of the generator contains three separate power supplies:

- The high voltage (kV) supply, which includes the inverter modules and the high voltage oil tank and other circuits, delivers up to 150 kV and up to 1000 mA (depending on model) between the anode and cathode of the X-ray tube.

- The filament supply board provides up to 6.5 amps to the selected filament in the X-ray tube. The X-ray tube current is monitored by the generator control electronics and fed back to the filament supply. The filament supply will make adjustments to the filament current in order to maintain a stable X-ray tube current over the length of the X-ray exposure.

- The rotor supply (LSS or DSS) contains the circuits needed to drive the stator windings of either one or two X-ray tubes.

7.1.2 High Voltage Power Supply (Cont)

The power supply includes the following major subassemblies:

- Integral to the high voltage power supply is the resonant circuit board. This assembly includes a current transformer used to control and protect the inverter modules, an output common mode choke for the inverters, and resonant inductors to optimize the inverter performance.

- The HT oil tank consists of high voltage transformers, filament transformers, high voltage rectifier power boards, tube selection relay on two tube tanks, and feedback circuits for the output kV and mA. The high voltage tank is capable of producing exposures of up to 80 kW and output voltages of up to 150 kV, depending on model.

- The power supply control board contains the feedback and control circuits for the high voltage tank as well as the over-voltage and over-current detection, and arc protection circuits. It also contains a voltage controlled oscillator for the gate pulse generator, which drives the FET's of the inverter module. This board connects to the control electronics through 37 pin and 15 pin D-connectors providing the transmission of key control signals between the power supply and the control electronics.

- The power supply control board contains the feedback and control circuits for the high voltage tank as well as the over-voltage and over-current detection, and arc protection circuits. It also contains a voltage controlled oscillator for the gate pulse generator, which drives the FET's of the inverter module. This board connects to the control electronics through 37 pin and 15 pin D-connectors providing the transmission of key control signals between the power supply and the control electronics.

- The power input board has the principle function of converting the mains power to a high voltage DC bus, which in turn provides the energy to the inverter modules. This board also contains other high voltage circuits, such as those for the soft start relays, the main contactor, and the EMI line filter components. The power input board has the principle function of converting the mains power to a high voltage DC buss, which in turn provides the energy to the inverter modules. This board also contains other high voltage circuits, such as those for the soft start relays, the main contactor, and the EMI line filter components.

7.1.3 Low Speed / Dual Speed Starter

- The low speed starter uses thyristor control to deliver nominally 240 VAC for a boost period of approximately 1.2 seconds. This boost period is required to get the anode of the tube up to speed at around 3200 rpm. At completion of the boost time, the stator voltage will be reduced to approximately 50 V for the run period, during which the correct tube speed is maintained for the length of the X-ray exposure.

- The dual speed starter uses a microprocessor controlled IGBT inverter to provide programmable boost and run voltages and programmable boost times to the stator windings of the X-ray tube. The DSS supply can operate at low speed (50 or 60 Hz) or high speed (150 or 180 Hz) and also provides DC braking. With microprocessor control, the DSS is able to maintain precise control of the rotor supply functions, which enables stable and optimum performance of the tube at either low or high speeds.

7.1.4 Generator Control Electronics

- The generator control electronics includes the microprocessor and control circuits that are essential to ensure the precise control of the power supply that is needed for state-of-the-art X-ray generators. Input and output (I/O) and auxiliary power circuits are also provided, to interface to the control console and to peripheral equipment in the X-ray system.

- The generator's executable code is stored in EPROM's in the console and generator CPU boards. Communication between the two CPU boards is provided through a serial link.

- The room interface board provides the terminal blocks, I/O and power circuits for interfacing the generator to the peripheral x-ray room equipment. This board also provides the connection to the generator safety interlock circuits. The output power and the I/O signal conditions can be programmed on this board through a number of relays and jumper terminals.

- The generator CPU board processes the feedback signals, and provides digital to analog and analog to digital conversion for the control signals. It provides reference voltages to and from the high voltage power supply and also contains up to four serial communications channels (one channel is dedicated to the console and can be configured as an RS232 or RS422 port, the second port is an RS232 port for the remote fluoro control, and the last two are optional RS232 ports for other use) and two timers. The programmable generator parameters are also stored on this board in battery backed-up RAM.

- The generator interface board interconnects most of the internal generator boards (AEC, CPU, rotor supply and room interface). Using opto-isolators this board isolates the I/O signals from the peripheral X-ray room equipment (connected to the room interface board), from the microprocessor and control circuits. This board also contains the power and interface circuits to the operator console. The generator interface board also provides the interconnection for other generator options, such as digital imaging and automatic exposure control.

- The optional automatic exposure control (AEC) board has up to four channels for connecting to four different image receptors with AEC capabilities. The board detects a voltage that corresponds to the quantity of radiation received by the image receptor during an exposure. When the threshold level for the desired exposure technique is received, the AEC board generates an exposure stop signal that immediately terminates the exposure.

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CHAPTER 8

SPARES

CONTENTS:

8.1.0 INTRODUCTION

This chapter contains the list of recommended spare parts for the various models of Indico 100 generators.

8.2.0 SPARE PARTS LIST INDICO 100 GENERATOR

DESCRIPTION	PART NUMBER	NOTE	SUGGESTED QTY
Generator CPU board	See note ⇒	1b	⇐ See note
Generator interface board	See note ⇒	1c	⇐ See note
Room interface board	733184-00	2	1
Power supply control board	732816-03	1a	1
Filament board	See note ⇒	3	⇐ See note
Auxiliary board	732221-02	4	1
Inverter board	See note ⇒	5	⇐ See note
Power input board	See note ⇒	6a	1
Resonant Board	See note ⇒	7	1
AEC board	See note ⇒	8	1
Console CPU board	See note ⇒	1b	⇐ See note
Console display board	See note ⇒	9	1
Display assy, LCD	See note ⇒	21	1
Remote fluoro display board	729053-00	10	⇐ See note
Remote fluoro control board	729038-00	10	⇐ See note
Low speed starter board	732752-00	11	⇐ See note
Digital I/O board	See note ⇒	18	⇐ See note
Dual speed starter board	728877-03	12	⇐ See note
Dual speed starter subassembly	See note ⇒	12	⇐ See note
Hand switch assembly	See note ⇒	22	⇐ See note
Battery, lithium 3.0V	7412290100	2	2
Capacitor, DC bus 470 uF 450 VDC	4150394100	13	6
Capacitor, DC bus 9000 uF 400 VDC	4155001400	14a	4
Contactor, line	SC2715	2	1
Diode, mains rectifier 160MT120K	6623071100	13	1
Diode, mains rectifier DD89N12K, DD90N12L, IRKD91-12	6623507000	14a	1
Fuse, A70QS10-14F	6739951800	12	7
Fuse, FNM-3	6711907400	2	5
Fuse, FNQ-10	6711905500	13	5
Fuse, GDC-1.6	5550033300	2	5
Fuse, GDC-2	5550032600	2	5
Fuse, GDC-2.5	5550034400	2	5
Fuse, GDC-5	5550035600	2	5
Fuse, MDA-5	6713000100	11	5
Fuse, MDA-7	6713000500	2	5
Fuse, MDA-10	6713000200	14a	5
Fuse, MDA-12	6713746500	2	5
Fuse, MDL-6/10	6713536000	6b	5
Fuse, MDL-1 1/2	6713541500	14b	5

8.2.0 SPARE PARTS LIST INDICO 100 GENERATOR (Cont)

DESCRIPTION	PART NUMBER	NOTE	SUGGESTED QTY
Fuse, MDL-4	6713544000	2	5
Fuse, NLN-100	6711906500	14a	5
Fuse, OTS-60	SC3434	13	5
Relay, DPST, 12V	7213011800	2	2
Connector, 4 pin	5618931800	12	1
Fan, axial	2084022900	20	1
Transformer, aux power supply	732417-00	2	1
Transformer, room I/F	See note ⇒	15	1
HT tank assembly (complete)	See note ⇒	16	⇐ See note

NOTE:

1a. The part number shown is the suggested replacement for the original power supply control board. The spares board is “full featured” and will replace the original board in your generator regardless of configuration. This is intended to eliminate the need to stock multiple configurations of this board.

1b. Two versions of generator CPU boards and three versions of console CPU boards are used in Indico 100 generators. Please confirm the original part number(s) of these boards in your generator before ordering spares. If your original generator CPU board is part number 732174-XX (where XX is a number from 00 to 08), order part number 732174-06. This part number replaces all configurations of 732174.

The generator CPU board and the console CPU board must be matched per the table below:

APPLICATION	GENERATOR CPU BOARD		CONSOLE CPU BOARD
23 X 56 cm console	If the original board is 732174-XX, order part number 732174-06 for spares usage	<MUST USE WITH>	732218-00
23 X 56 cm console	734573-00	<MUST USE WITH>	733903-00
31 X 42 cm console	734573-00	<MUST USE WITH>	735852-00

1c. Two different generator interface boards are used in Indico 100 generators. For rad and R&F generators, use part number 732177-06, for pulsed fluoro generators use part number 732177-08. Spares should be stocked accordingly.

2. This part is common to all models of Indico 100 generators.

3. Three different filament boards are used in Indico 100 generators. RAD only generators use ONE filament board, part number 731407-00. R&F generators use TWO filament boards, part number 731407-01 (large focus) and part number 731407-02 (small focus). Spares should be stocked accordingly.

4. The part number shown is the suggested replacement for the original auxiliary board. The spares board is “jumper configurable” in the field and as such will replace the original auxiliary board. This is intended to eliminate the need to stock multiple configurations of this board.

NOTE (Cont):

5. Three different inverter board part numbers are used in Indico 100 generators. For 230 VAC 1 phase and 480 VAC 3 phase generators use part number 732813-00, for 400 VAC 3 phase 30 / 50 / 80 kW generators use part number 732813-04, for 230 VAC 1 phase 37.5 kW and for 400 VAC 3 phase 37.5 / 65 kW generators use part number 732813-05 (see note 17 for the definition of mains input voltage). 30 and 37.5 kW generators require one inverter board, 50 and 65 kW generators require two inverter boards, and 80 kW generators require three inverter boards. Spares should be stocked accordingly.

6a. Two part numbers of power input boards are used for spares. For 1 phase 230 VAC generators use part number 733798-01, for 3 phase 400 or 480 VAC generators use part number 732161-01.

6b. This fuse is used on all rad two tube generators, and on all R & F one tube and two tube generators. Spares should be stocked accordingly.

7. Five different resonant boards are used in Indico 100 generators. Refer to the table below for the correct part number for your generator.

O/P POWER (kW) & MAINS VOLTS	RESONANT BOARD RAD POWER SUPPLIES	RESONANT BOARD R&F POWER SUPPLIES
30 kW (230 VAC 1ϕ, 400 / 480 VAC 3ϕ)	732808-00	
37.5 / 40 kW (230 VAC 1ϕ, 400 VAC 3ϕ)	732808-05	732964-02
50 kW (400 VAC 3ϕ)	732808-01	732964-00
50 kW (480 VAC 3ϕ)	732808-02	
65 kW (400 VAC 3ϕ)	732808-06	732964-03
80 kW (400 VAC 3ϕ)		732964-01
80 kW (400 / 480 VAC 3ϕ)	732808-03	

8. The AEC board for your generator was selected to be compatible with specific AEC device(s). To maintain full compatibility, the original part number must be ordered as a replacement. Refer to chapter 9, section 9.2.0 for the part number of the original AEC board shipped in the generator for which this manual was prepared.

9. The console display board is supplied pre-mounted to the console front panel switch assembly. To determine the required spares part number for this assembly, refer to the table below. ***CONSOLE DISPLAY BOARD ONLY USED WITH THE 23 X 56 CM CONSOLE.***

DESCRIPTION	SWITCH/DISPLAY ASSY PART NO
SWITCH/DISPLAY ASSY, R&F, ENGLISH	734429-00
SWITCH/DISPLAY ASSY, R&F, GERMAN	734429-01
SWITCH/DISPLAY ASSY, RAD, ENGLISH	734430-00
SWITCH/DISPLAY ASSY, RAD, GERMAN	734430-01

10. Remote fluoro control is an option, spares should be stocked accordingly.

11. These items only used on generators fitted with low speed starter, spares should be stocked accordingly.

NOTE (Cont):

12. These items only used on dual speed starter option, spares should be stocked accordingly. Several part numbers of dual speed starter (which are tube stator dependent) are used in Indico 100 generators. To determine which dual speed starter assembly is in your generator, note the DUAL SPEED STARTER ASSY part number on a label on the dual speed starter chassis. This will be the part number that must be ordered for spares usage. For reference, this will be part number 733317-XX or 735925-XX where XX is a two digit number designating the exact configuration.

    The dual speed starter fuses listed are used on all four versions of dual speed starter.

13. These items are used on the 400/480 VAC 3 phase power input board. Spares should be stocked accordingly.

14a. These items are used on 1 phase 230 VAC units only (on the DC bus assembly or on the 1 phase power input board). Spares should be stocked accordingly.

14b. This fuse used on 1 phase 230 VAC rad two tube generators, and on 1 phase 230 VAC R & F one tube and two tube generators. Spares should be stocked accordingly.

15. Two different room I/F transformers are used in Indico 100 generators. For 230 VAC 1 phase generators use part number 733685-00, for 400 and 480 VAC 3 phase generators use part number 732179-00.

16. For replacement HT oil tank part numbers, consult factory.

17. ***NOTE REGARDING MAINS (LINE) VOLTAGE AS DESCRIBED IN THIS SECTION:*** The mains voltage referenced in this section is the mains voltage at the input to the ***generator*** (at the main fuses on the power input board). This is not necessarily the same as the voltage at the main disconnect box in the room, the reason being that an optional line adjusting transformer may be used with the generator which steps the incoming line voltage to the generator up or down. To ensure that the correct part number is selected for spares, it is suggested that the mains voltage be noted at the main input fuses INSIDE THE GENERATOR.

18. The digital I/O board is optional, and used on generators intended to interface with digital imaging systems. To ensure full compatibility, please order the same part number that is in your generator(s).

19. The hand switch assembly is optional, and is normally dealer installed.

20. A cooling fan is used on R&F power supplies only. Spares should be stocked accordingly.

21. For 23 X 56 cm consoles, use LCD display assembly part number 733396-00. For 31 X 42 cm consoles, use LCD display assembly part number 735895-00.

22. For 23 X 56 cm consoles, use hand switch assembly part number 733176-00. For 31 X 42 cm consoles, use hand switch assembly part number 735203-00.

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CHAPTER 9

SCHEMATICS

CONTENTS:

9.1.0 INTRODUCTION

This chapter contains the functional schematics for your X-ray generator. Each schematic represents a major function in the Indico 100 generator; the fourteen functional schematics in this chapter represent all of the major functional blocks in Indico 100 generators.

9.2.0 FUNCTIONAL SCHEMATIC INDEX

The functional schematic index follows this page. The part number for the AEC board originally shipped in your generator is listed at the bottom of this form.

9.3.0 FUNCTIONAL DRAWINGS

The functional schematics immediately follow the functional schematic index.

REPLACE PAGE 9-3 WITH "FUNCTIONAL DRAWING INDEX" FORM MF-0718

THE ASSEMBLY PART NUMBER FOR THE AEC BOARD IS TO BE TAKEN FROM THE AS-BUILT RECORD:

USE

"PWBA, DEDICATED AEC"
OR
"UNIVERSAL AEC, FINAL ASSY"

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